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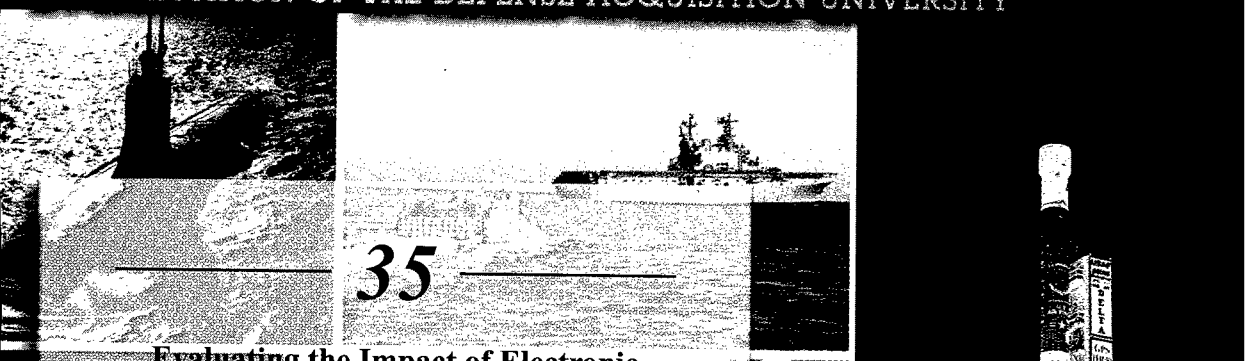

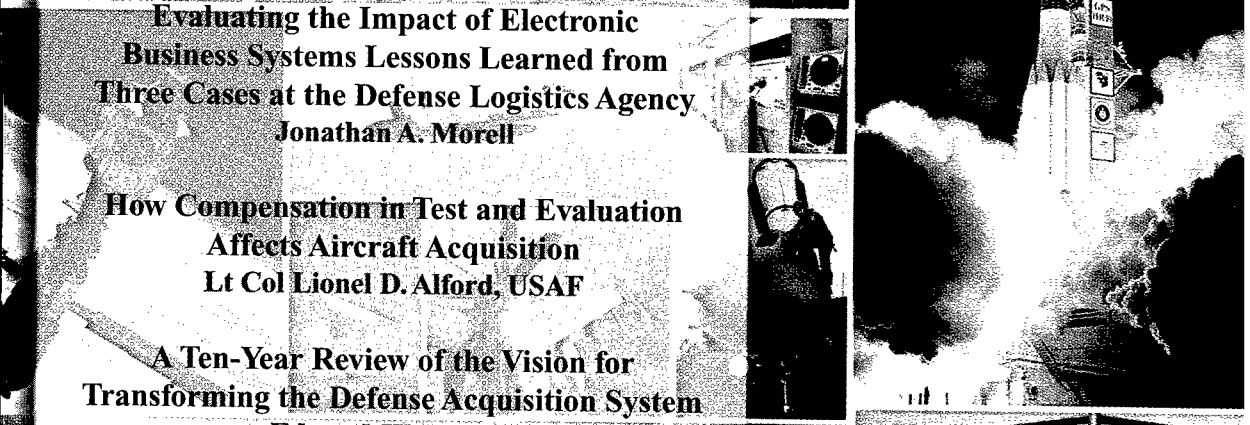

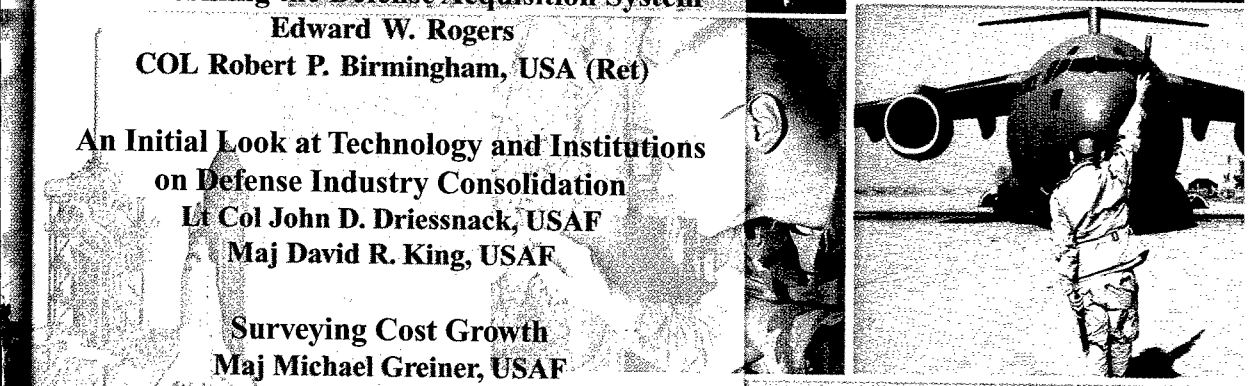

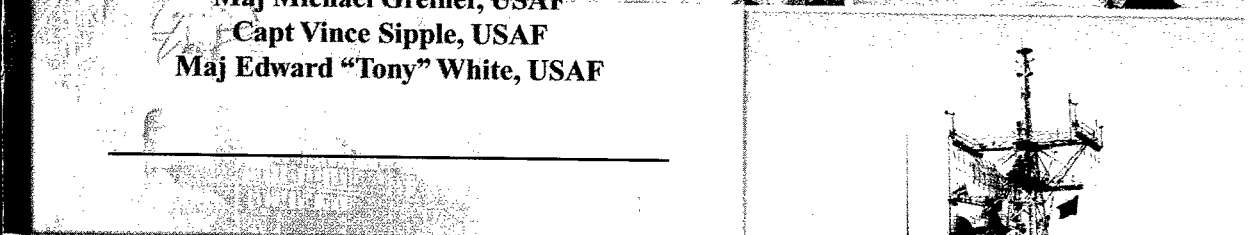

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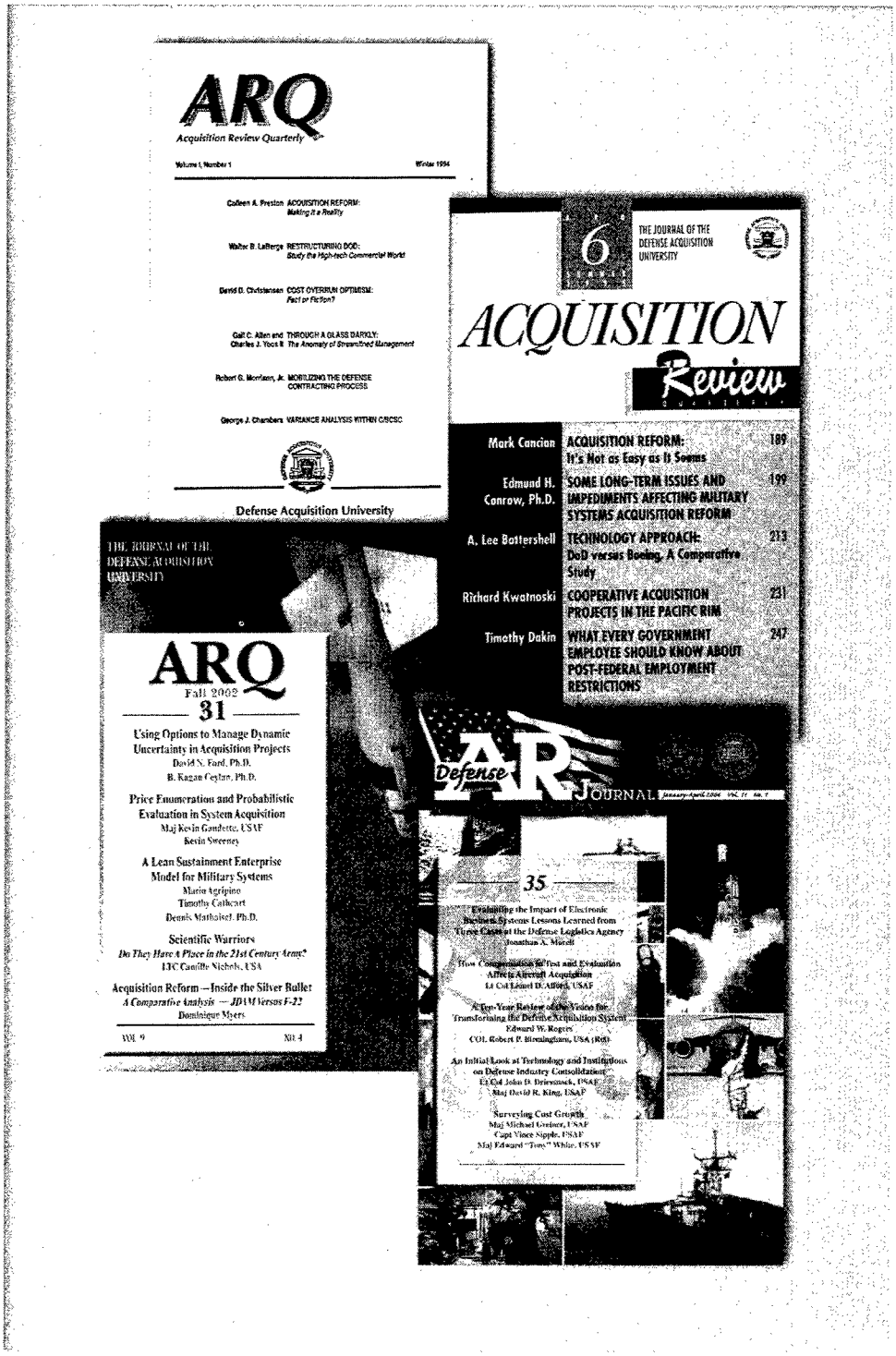
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NOTE FROM THE MANAGING EDITOR

INTRODUCTION OF THE NEW *DEFENSE ACQUISITION REVIEW* JOURNAL (*ARJ*)

Since the inaugural edition printed in the winter of 1994, the *Acquisition Review Quarterly* (*ARQ*) journal remains loyal to its original intent — to focus on the needs of acquisition professionals across discipline, serve as a tool for the fostering and dissemination of scholarly research relating to the acquisition community, provide a platform for the exchange of policies and opinions, as well as create a forum of debate and discussion on issues that directly affect the acquisition workforce.

AN ACQUISITION FIRST

As the first publication to *specifically* address the needs of the acquisition workforce, the *ARQ* continues to stay current with a rapidly changing Department of Defense (DoD) from transformations in the Department's mission, to the establishment and implementation of new business processes. And in light of these changes, this publication is making a few changes of its own to include a new name — the *Defense Acquisition Review Journal* (*ARJ*) — and the adoption of a triannual print schedule producing three issues a year (April, August, and December) versus printing four issues on a quarterly schedule. Please be advised, there is no Fall 2003 edition of the *ARQ*. Instead, all efforts went toward the production of the edition that you now hold in your hands.

OUR COMMITMENT

We as members of the Defense Acquisition University Press, stand firm on our commitment to produce a premier acquisition publication that meets the needs of the acquisition workforce, and I invite you to play an active role in helping us to exceed this goal by submitting manuscripts, becoming a peer reviewer, spreading the word about the journal, participating in surveys, and writing letters to the editor to give us feedback on ways that the journal can better service the DoD Acquisition, Technology, and Logistics workforce.

Norene L. Fagan-Blanch
Managing Editor
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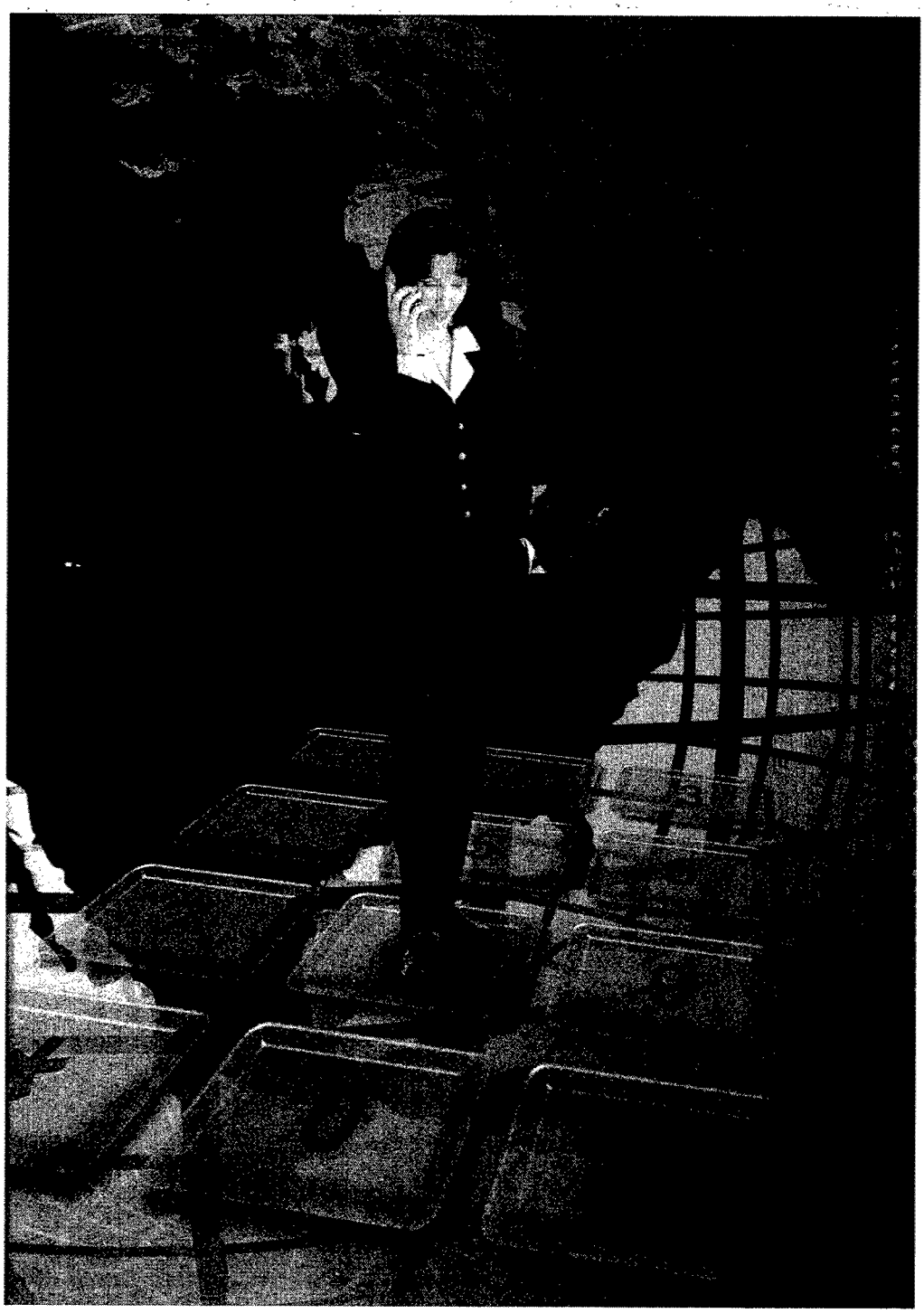


EVALUATING THE IMPACT OF ELECTRONIC BUSINESS SYSTEMS *LESSONS LEARNED FROM THREE CASES AT THE DEFENSE LOGISTICS AGENCY*

Jonathan A. Morell, Ph.D.

This article synthesizes our experience evaluating three electronic business (eBusiness) systems in the Defense Logistics Agency. The focus was on actual impact in real life operational settings. We summarize our experience in terms of lessons learned and make a case that our experience can help others do similar evaluation. Lessons learned are grouped into six categories: metrics and data sources, methodology, program logic, adaptive systems, realistic expectations, and dependencies among the previous five.

This article synthesizes our experience evaluating the impact of three electronic business (eBusiness) systems in the Defense Logistics Agency (DLA). Our intention is to show the tactics that emerged when general principles of evaluation were applied for the context-specific purpose of determining whether, and how, an eBusiness system is affecting its environment. The first section outlines our emphasis on impact assessment and makes a case for evaluating eBusiness systems. The second section presents *lessons learned* that were abstracted from our experiences and that can be applied to other, similar evaluation exercises. Finally, we illustrate how the lessons learned were combined to produce impact assessments of particular eBusiness programs.

Impact Assessment — Difficulties and Imperatives

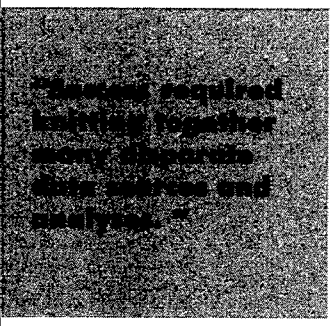
Our evaluation activities assumed that programs that have been deployed should have measurable consequences. In this we

are firmly rooted in the tradition of evaluation for impact assessment. This view, as summarized in a classic evaluation textbook, states that:

> The critical issue in impact evaluation, therefore, is whether a program produces desired effects over and above what would have occurred either without the intervention, or in some cases, with an alternate intervention. (Rossi, Freeman, & Lipsey, 1999, p. 239)

Our core challenge in making such an assessment was the need for a methodology that could produce causal information within a context that from our evaluator's perspective, was totally uncontrolled. We had to evaluate a *natural experiment*, i.e., a situation in which "... program variants (or other treatments of interest) are not experimentally controlled but vary in the natural environment and in which causal inference is still desired." (Mark, Henry, & Julnes, 2000, p. 265).

In the present case, not only was the situation uncontrolled, but also entirely post hoc. Evaluation did not begin until after the programs in question were well established. As a result of the timing, it was impossible to influence implementation schedules, to anticipate data needs, or to establish data collection mechanisms. Of necessity, the evaluation design was *quasi-experimental*, an approach defined by Rossi, Freeman, & Lipsey (1999) "An impact assessment in which 'experimental' and 'control' groups are formed by a procedure other than random assignment" (1999, p. 234). Data limitations, however, made it necessary to formulate tactics that went beyond simple comparisons of non-equivalent control groups. Success required knitting together many disparate data sources and analyses. Much of what will be reported below is the story of the search for those sources and the logic and methodologies used to integrate them.



Because of our emphasis on outcome assessment, we did not dwell on process metrics such as percentage of time a system was running, average time to resolve complaints, or number of users. Rather, we focused on whether, because the system was working, there was measurable impact on dollars, quality, time, or readiness. The objective was to determine whether, for operational eBusiness systems, it would be possible to:

- Obtain relevant data.
- Draw conclusions about what the program accomplished.
- Develop practical recommendations to facilitate further evaluation.

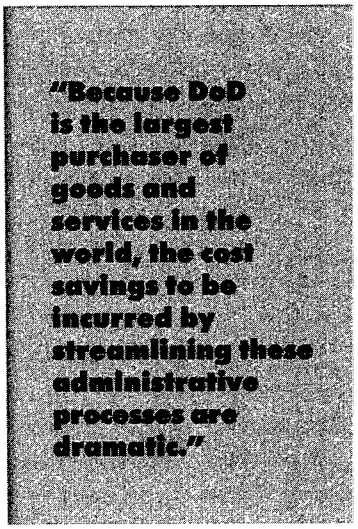
The answer was by no means certain because very few eBusiness programs are implemented in a way that is conducive to impact evaluation. To anticipate the later discussion, limitations on IT systems and inter-organizational agreements conspire to constrain evaluation possibilities. We discovered that despite these problems, it was possible to assess impact for each of these systems. This finding gives

us confidence (but no guarantee) that impact evaluation can also be conducted on other operational eBusiness systems. By presenting this information, we hope to convey a sensibility about how this kind of work can be done, and thus, to spur more such activity by a larger number of people. At the DLA's request, three eBusiness systems were studied: Electronic Document Access (EDA), Central Contractor Registration (CCR), and the Department of Defense (DoD) Emall.

EDA (http://eda.ogden.disa.mil/eda_main.htm): The Electronic Document Access Web (EDA Web) combines Internet and World Wide Web technologies with electronic document management to eliminate paper files and facilitate information sharing among DoD communities to provide access to single-source DoD official documents. The information is maintained and available for access to authorized users in Portable Document Format (PDF). Documents included in EDA include contracts and contract modifications, MAAPR (materiel acceptance and accounts payable report), government bills of lading, and DD1716 forms (Contract Data Package).

CCR (http://www.ccr.gov/): In the past, any vendor who wanted to do business with more than one DoD site was required to submit the same business information to each and every site. This redundancy of paperwork not only created an administrative burden for both the government and the vendor, but also was a major source of administrative error and expense in terms of both time and money. Because DoD is the largest purchaser of goods and services in the world, the cost savings to be incurred by streamlining these administrative processes are dramatic. CCR was created to be the single repository of vendor data for the entire DoD to avoid this administrative duplication and allow contractors to take responsibility for the accuracy of their own important business information by supplying it directly to the government through a single registration.

DoD Emall (https://emall.prod.dodonline.net/scripts/EMlogon.asp): The DoD Emall strives to be the single entry point for purchasers to find and acquire off-the-shelf, finished goods items from the commercial marketplace and government sources.



The evaluation work discussed here took place between 1999 and 2001. The specific findings are frozen in time, while the programs themselves have been evolving. Thus, conclusions concerning the systems that were evaluated may not be useful for current decision making. However, we believe that the lessons learned from that work are applicable to evaluation of other eBusiness systems in government settings.

Few impact evaluations of IT systems take place in government settings. But to calibrate expectations, it is important to realize that few such studies exist for any sector. Most of the research on the impact of IT focuses at its lowest level on the firm, and aggregates up from there. Much of this research deals with what is commonly known as the *productivity*

paradox, i.e., the disconnect between our intuitive sense that IT *must* have a beneficial impact, and the failure of researchers to observe that impact (Brynjolfsson, & Hitt, 1998; Chan, 2000; Macdonald, 2002).

"Despite the difficulties, impact assessment of DoD eBusiness systems is needed to build a fund of knowledge, experience, and wisdom about what works."

A second body of research on IT deals with the role that IT plays in particular business processes. For instance, Malone and Crowston (1994) assess how IT affects inter-firm transaction costs, and by so doing, influences decisions about trading partner relationships. A similar focus is exhibited by Argyres (1999) in his research on how IT affected inter-organizational relationships during the development of the B-2 bomber. Studies like these make a good case that IT can play an important and beneficial role in shaping decisions about how an organization should behave. However, the focus of most existing research and evaluation is on particular processes, and is not cast in the form: "System X was implemented. What impact did it have?"

The reason this kind of evaluation is difficult is because when specific eBusiness systems are evaluated within a larger organizational context, four challenges to good measurement and good methodology are almost always present.

1. The system in question seeks to provide specific and limited improvements within a complex context of multiple interacting business processes and applications.
2. While the system may provide specific assistance to a well-defined group of users, it may also contribute to an overall information infrastructure. In contributing to the infrastructure, the system makes additional, and more diffuse, contributions to the development of other systems and to creative problem solving.
3. At the same time the system is being developed, other systems may also be under development.
4. Plans for impact assessment are not put in place during the programs' development or initial deployment.

Despite the difficulties, impact assessment of DoD eBusiness systems is needed to build a fund of knowledge, experience, and wisdom about what works. As this understanding spreads within the DoD system development community, new systems will become more effective and more accountable.

In the next section we present lessons learned and examples of their application to the evaluations that were conducted. The subsequent section takes a deeper dive into the EDA evaluation and illustrates the lessons learned in greater detail.

Lessons Learned

Unambiguous instructions for doing post hoc outcome evaluation are impossible because evaluation settings differ with respect to the functionality of the system being evaluated, comparisons that can be drawn, data available, user base, and implementation schedules.

Collectively, these differences are bound to have major consequences for choices about design and analysis. Rather than be prescriptive, the intent of this section is to convey a sense of what issues must be considered, and how choices might be weighed, when deciding on how to conduct post hoc evaluation of eBusiness systems. The discussion is organized by lessons learned in six general categories:

1. Metrics and data sources.
2. Methodology.
3. Program logic.
4. Adaptive systems.
5. Realistic expectations.
6. Interactions among lessons learned.

Metrics and Data Sources[1]

All relevant metrics are categories and combinations of dollars, quality, time, and readiness. The challenge is to define exemplars of these metrics such that trusted numbers can be found and analyzed. One major problem is that evaluation is usually commissioned by a system's owners. While those owners can provide rich process data (e.g., number of users, up-time, development cost), they usually do not control data relevant to impact. Those data tend to be owned either by a system's users, or a third party data collection function. To illustrate, owners of EDA believed that their system had a positive affect on the ability of the DoD to pay invoices on time. Making that case, however, required getting data from the Defense Finance and Accounting Service (DFAS), an organization with which the evaluators had neither personal nor contractual relationships.

A derivative problem is that even if data owners are willing to help, their information systems may lack the capacity to yield the fine-grained data needed to evaluate a particular program. Further, no matter how big an organization, any given database is likely to have no more than two to five people who understand the database in sufficient detail to advise as to what information can, and cannot, be extracted. Moreover, the identities of these people are difficult to ascertain because they tend to be organizationally distant from whatever point of contact an evaluation team may have, and also because job changes often necessitate talking to people about their former, not their present, jobs.

"Further, no matter how big an organization, any given database is likely to have no more than two to five people who understand the database in sufficient detail to advise as to what information can, and cannot, be extracted."

The above problems are exacerbated by the fact that *multiple* sources of data are likely to be needed. Thus efforts to find, get, and access information are multiplied. To illustrate, consider the complexity of information used in our evaluation of CCR.

- Relevant information came from the Department of the Treasury, data archives at three different DLA organizations, and the personal knowledge of many different people.
- Electronic Funds Transfer (EFT) volume and contract transaction volume

were needed to construct ratios of actual savings to real savings. To do this, two different sources of contract volume were helpful in improving estimation accuracy.

- CCR implementation timelines were needed to assess the likely course of events, had CCR not been available. Transactions costs from the Treasury study were combined with transaction volume data to assess overall impact.

- Qualitative knowledge about CCR's role in process improvement led to a logic model, which dictated the analysis strategy.

Methodology[2]

"Methodology is the logical structure in which data collection and analysis are carried out."

Methodology is the logical structure in which data collection and analysis are carried out. Without a clear sense of that logic, there is no way to know what to do with metrics. For instance, an evaluation of EDA might require using the metric *time from a contract being finalized to its arrival at the Defense Contract Management Agency* (DCMA). But how should this metric be used to draw inference about EDA? Is it necessary to track the metric weekly, monthly, or annually? Is it necessary to compare data at different locations within DCMA? Is there a need to differentiate between kinds of contracts? Is it necessary to obtain historical baseline data, or will current information suffice? Would it be beneficial to compare contract transmittal time to DCMA with transmittal time to other agencies? Answers to these kinds of questions make a practical and significant difference for the kind of evaluation that can be done.

While the above example deals with a fine-grained metric, the problem scales. For instance, another metric might be development costs for IT systems, to be measured as part of an assessment of the accomplishments of the Clinger-Cohen Act. There is no doubt that the federal government has many metrics relating to the cost of IT systems. But would it be possible to compare these costs over a twenty-year period? Have the components of the metric changed over the years, and if so, have they changed in a way that invalidates historical comparison? Or, perhaps different federal agencies implemented the act in different years. Is the time difference in implementation, compared to the time scale of the metrics, conducive to comparison across agencies? Would the data allow sub-department level comparison? Depending on the answers to these questions, it may or may not be possible to implement different evaluation methodologies.

Program Logic

Choosing metrics and methodologies is greatly aided by developing a *program logic model* in order to answer the question: If the system works as planned, what will be different? This may not be an easy question to answer. A program's impact can be broader than indicated by meeting requirements for well-defined user groups. Proximate impact may induce secondary change. Time frames for impact may vary — some changes may occur immediately

upon system implementation, while other changes may develop over years.

Outcomes may interact with each other. By representing these phenomena in pictorial or tabular form, logic models force evaluators to identify what to measure, what measurements to compare, and when data analysis should take place. Developing these models has the added advantage of forcing collaboration between evaluators and stakeholders, and in achieving consensus among stakeholders as to what outcomes should be measured. (The field of Evaluation has a long history and extensive literature on developing logic models to drive evaluation. For an introduction, see Renger and Titcomb [2002].)

Adaptive Systems

The uses of eBusiness systems are not static. Of course all such systems have *core uses* that are enshrined in requirements and justification documents. These uses represent the main reasons a system was built, and their evaluation must carry through time. Focusing *only* on these uses, however, is almost certain to miss many important impacts. (Whether these are desirable or undesirable is an empirical question.) Any new eBusiness system represents a bundle of functionality that constitutes a tool people can use to solve problems.

As users become comfortable with their new tools, they will recognize new uses for the tools. These uses cannot be anticipated because experience with a tool is often a prerequisite for appreciating its value. Another reason is that personnel change over time and bring new skills and new perspectives to their jobs. Additionally, the environment in which systems operate is not stable. It is entirely possible that by the time a system is fully deployed, new reasons to use it will appear. (The opposite may also be true. The original need for a system may disappear. This too, must be included in evaluation.)

"Any new eBusiness system represents a bundle of functionality that constitutes a tool people can use to solve problems."

A good example of newfound use is the case of CCR. CCR was originally conceived as a method of decreasing labor for data input by government personnel, decreasing the number of times contractors had to provide the same data, and increasing data accuracy. All these were worthy goals, which may have justified CCR. However, as CCR developed, its true power came to be realized. For the first time, the government had a single, unambiguous identifier for all government contractors, a number that remained constant and reliable across contracts and across contracting activities. This ability turned out to have major benefits. For instance, it was instrumental in facilitating the government's move to electronic payment of invoices.

Realistic Expectations

One of the most frequent questions evaluators asks is some variant of: "What are your expectations for what this system will accomplish?" The usual answers are almost always wildly optimistic. Perhaps a system's owners can't get out of selling mode, or perhaps they have come to believe their own rhetoric — but for whatever reason, claims about a

system's accomplishments are often far beyond any reasonable boundaries of real world impact. Woe to the evaluator who takes these statements at face value and proceeds to do an excellent job of measuring the program relative to those projected outcomes. And woe to the program's owners, who will receive only bad news about the value of their efforts. The disappointment has real and important consequences.

First, program managers do need to justify their programs. Evaluation relative to impossible goals will not provide that justification. Second, program managers need evaluation data to help them build on accomplishments. Without knowledge of what actually happened, needed guidance is missing. Third, evaluation almost always requires the cooperation of those being evaluated. Over time, assessment that brings only bad news will poison the climate for doing evaluation.

While almost everyone has an intuitive understanding of these dynamics, we have found that the generic logic model shown in Figure 1 is extremely useful in driving the point home and in facilitating the kinds of conversation needed to identify measurable achievements. Figure 1 depicts a program made up of four processes. An eBusiness system is implemented for the purpose of lowering the program's overall costs. Upon close inspection though, it's obvious that the new business system will affect only Process Four.

While the new eBusiness system may improve Process Four, it may not change the total cost of doing business because mission change, or high level reorganization, may affect the scale of the program's activities. Also, changes in Process Four may facilitate other internal changes within the program. Using a picture like Figure 1 helps get stakeholders to address crucial questions about scope.

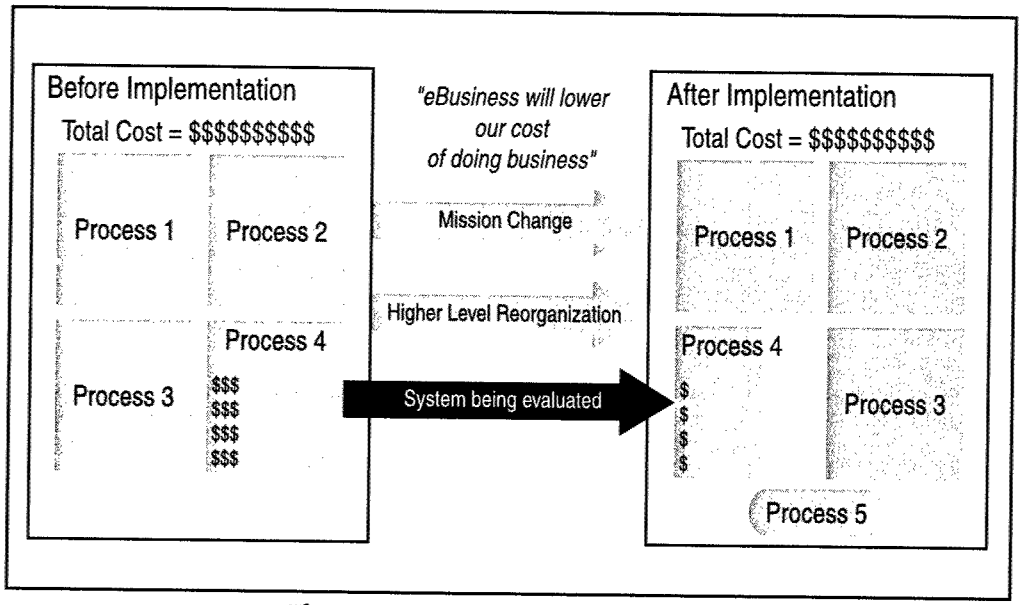


Figure 1. Realistic Expectations

What specific process will be affected? If those processes were improved, how much total change in the organization could be expected? If new functionality became available, what new processes might appear? What external forces are operating that might affect the impact of the system being evaluated?

Of course evaluators must not cook the books. There is a duty and an obligation to provide accurate information, even when that information will work to the detriment of some stakeholders. Programs are justified to funders based on specific claims, and it is important to hold managers to their claims. The solution is to employ a variety of tactics. First, the messy world of program justification and development is a web of political, budgetary, and bureaucratic forces that requires successful managers to make different claims, in different ways, to a variety of groups. While some of those claims will be core justifications that must be evaluated, others will not.

Second, eBusiness systems will have intermediate and localized impacts that are desirable, and that provide useful feedback for program improvement. These must be measured. (Of course not all the local or intermediate outcomes may be desirable, and these too must be assessed. Not only is doing so necessary for a fair evaluation, but the information can also be extremely useful for designing mid-course corrections.)

Interactions Among Lessons Learned

For the sake of exposition, the lessons learned were presented as if each were distinct and independent. In reality, they are inextricably linked. The process of evaluation should be seen as a continual scanning for these relationships as the life cycle of an evaluation unfolds. A good example of this process involves the interaction between *data sources* and *methodology*.

"The process of evaluation should be seen as a continual scanning for these relationships as the life cycle of an evaluation unfolds."

One of our early plans for an evaluation design was a time series analysis of a particular transaction at a particular agency. The idea was to compare trends before and after implementation. The plan seemed especially appealing because we knew that the system had been introduced at different times in different parts of the organization. Our team was attracted to the possibility of making comparisons both over time and across organizational subunits. We formed this plan because trusted informants assured us that the data we needed had been collected over a long period. This information proved correct, but other facts emerged as we investigated the possibility of getting that data.

First, the older information was contained in a system that had been phased out and, while theoretically available, was not obtainable in practical terms. Second, the data were not collected at frequent enough intervals over the several years we needed to provide enough data points. Third, the way in which a critical data field was defined had changed over time, thus making historical comparisons problematic. Finally, the agency itself had changed organizational structure over the years. As a result, it was not possible to compare change over time either within, or across, the various subunits. In light of these

discoveries, it was necessary to abandon the time series methodology in favor of more localized comparisons.

In terms of the practice of evaluation, it is important to note that our initial plan was based on information from well-meaning people with good knowledge of the eBusiness system involved, the agency in which it was used, and the data that were generated. However, it was only after we had a chance to talk to many mid-level and lower-level personnel that we were able to get the specifics needed to make an informed judgment about whether a time series methodology was practical.

Applying Lessons Learned: The Example of Electronic Document Access

Electronic Document Access affects so many processes that a wide variety of input was needed to make decisions about logic models, metrics, and methods. The organizations whose input influenced the EDA evaluation included the: Defense Contract Audit Agency, Defense Contract Management Agency, Defense Finance & Accounting Service, Defense Information Systems Agency, Defense Logistics Agency, Directorate for Information Operations and Reports, Fitting Out and Supply Support Assistance Center (FOSSAC), Navy/Air Force Interface, Office of the Secretary of Defense — CIO Office, and several Army Commands.

At the time this work was carried out, the most extensive use of EDA was for the management of contracts and contract modifications. Thus "contracts" became our primary focus. Potential metrics were cast within a Balanced Scorecard framework because at the time of this project, Balanced Scorecard was being heavily used in the DLA.[3] We felt that even though our work was unrelated to that Balanced Scorecard activity, using Balanced Scorecard categories would help our

Table 1. Reasons for EDA Impact

Business Process	Balanced Scorecard Category	Reason why EDA may be Helpful
DFAS invoice processing	Financial	DFAS requires complete paperwork before it can process an invoice. EDA: 1 - reduces time from document creation to its arrival at DFAS, and 2 - assures a single complete set of contracts and associated modification. The result is decreased time for invoice processing, fewer aged invoices, and better compliance with the Prompt Payment Act.
Contract/mod creation, distribution	Financial Internal process	EDA has the potential to decrease labor effort for contract management, and as such, has financial implications. Consistent with any organization's ability to adapt to circumstance, decreased labor effort for any given task will result in a reordering of work priorities, or the development of new processes.

stakeholders form useful linkages among parallel, but conceptually related, activities.

Using a logic model perspective, we articulated why EDA should affect the metrics identified. The mechanisms of action are presented in Table 1. (Table 1 also illustrates the notion that while logic models are usually represented in graphical fashion, tabular descriptions can also be useful.)

EDA Impact: Contract Processing Labor and Interest Saved on Overaged Invoices

Data used in this analysis, and their sources, appear in Table 2. This analysis again illustrates the need for multiple sources of data, some of which reside in data archives, and some of which were developed for a specific, empirical investigation of a program. In the present case, the data came from FOSSAC's detailed and careful assessment of how EDA affected their contract processing efforts. For their contracts, we had good information on labor hours and interest payments due to over aged invoices for the 2000 and 2001 fiscal years, i.e., the time immediately before and immediately after the adoption of EDA.

The limitation on the FOSSAC assessment was that it covered only a small number of contracts. To scale up the findings, it was necessary to determine the historical number of similar *paperless* transactions for the whole Department. The extra effort to determine the percent paperless

Table 2. Data Used in Assessment of EDA Impact on Contract Processing Labor

Data	Use	Source
Historical data on DFAS workload	Contextual understanding of how DFAS worked, the pressures operating on the Service, and why better access might be important.	DFAS
Per-contract impact of EDA, time before and after EDA implementation at the Fitting Out and Supply Assistance Center (FOSSAC)	Hard data on change due to EDA. Used as basis for scaling up estimate to the DoD.	FOSSAC*
Contract volume per year for DLA, Air Force, Army, Navy	Used to scale up local impact to DoD.	1 - OSD CIO Office 2 - DD350 database
% paperless transactions	EDA only contributes to change for processing of paperless transactions. "% paperless" is needed to avoid applying analysis to the total contract volume.	1 - OSD CIO Office 2 - DD350 database

* Data courtesy of Bonnie Brown-Murphy, Management Program Analyst, Fitting Out Supply Support Assistance Center, Special Projects. Original source: Electronic Commerce Solutions Corporate Information Management Board, Paperless Working Group, Oct 9, 2001.

Table 3. Hours Made Available Due to EDA

Year	98	99	00	01	02	Total
Hours/year	3.8K	42.4K	49.8K	51.7K	51.7K	250.9K

was critical because although it is relatively easy to find the total number of contracts, EDA provides labor savings *only* for that percentage of the transactions that were paperless. As a result, two data sources had to be used: the first on contract transaction volume, and the second, on paperless transactions. To make this determination, two data sources were combined.

The first was information on total contract volume. The second was percent paperless data that began with FY98 and ended with the third quarter of FY01. Using all this information, it was possible to calculate both the number of labor hours that were no longer required for contract processing due to EDA and the savings in interest payments due to EDA. This information is summarized in Tables 3 and 4. Data were projected several years into the future. We ended the analysis at FY03 because while projections into the future are legitimate, the further the projection, the greater the inaccuracy. Also, we had reason to believe that another program —

Table 4.
$M Savings, Interest on Overaged Invoices Attributable to EDA

Agency	FY97	98	99	00	01	02	03	Total
Army		0.35	0.79	0.95	0.95	0.95	0.95	4.94
Navy			0.45	0.99	1.30	1.30	1.30	5.34
Air Force				0.44	0.52	0.52	0.52	2.00
DLA			7.14	7.43	7.44	7.44	7.44	36.89
Total		0.35	8.38	9.81	10.21	10.21	10.21	49.17
Cumulative		0.35	8.73	18.54	28.75	38.96	49.17	
ROI								
NPV of Savings								43.31
Investment	2.6	1.0	1.0	1.0	1.0	1.0	0.5	
NPV of Investments								7.33
ROI								5.91

Notes:
1. Conservative estimate. Does not include impact on discounts earned, bills of lading, vouchers, MAAPR, DD1716, or $ value of new activities.
2. 02/03 projections based on 00/01 data.
3. Unadjusted $.
4. Return on Investment (ROI).
5. Net Present Value (NPV)

Wide Area Work Flow (WAWF) — would come on-line in about three years, at which point the unique impact of EDA would be blurred by the combined consequences of both programs.

The approach taken here highlights possible interactions between decisions made about metrics and decisions made about methodologies. Our initial inclination was to find one or two metrics that indicated the impact of EDA and that could be collected on an organizationwide basis. Had we been able to do this, some relatively simple comparisons or time series analyses would have sufficed to provide the information we were after. Once we learned that no such metrics were possible, we began to cast about for alternate metrics and, as we did so, for methodologies that could exploit those metrics. This process led to the tactics we actually used, i.e., we took a micro-level view of good impact data and brought in multiple data sources to scale up the findings to a broader level.

The data in Tables 3 and 4 illustrate some of the limits that must be accepted when doing post-hoc evaluation of this type. While we could estimate the number of hours that no longer had to be devoted to contract processing, we were *not* able to determine how organizations adapted to that change. Unanswered questions included: Did they decrease their labor force? Did they reorganize? Did they deploy the workforce to other, truly value added activities? Any of these (in multiple combinations) were possible and were likely to vary from setting to setting. Because no mechanisms were in place to get the needed data, a comprehensive evaluation would have required

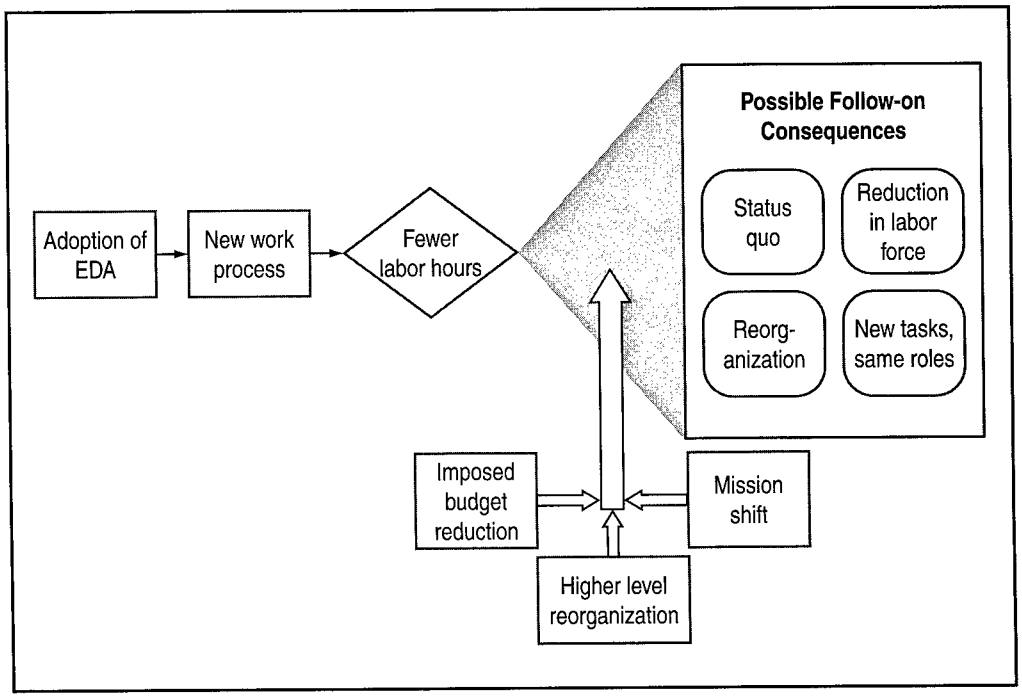


Figure 2. EDA: Direct Impact and Second-Order Consequences

an impractical plan that far exceeded available resources. First, it would have been necessary to identify the locations where these changes had been taking place. Second, different methodologies would have been required for each set of outcomes.

The problem of data access is a practical limitation, but another limit touches on the fundamental question of what impacts should be expected from any given program. To understand the issue, logic modules can be of assistance. Figure 2 illustrates that while *labor hour savings* can reasonably be expected to result directly from EDA, the follow-on consequences of labor hour savings are affected by powerful forces that EDA cannot influence. The immediate impact of EDA is that as people start to use it, they spend less time in the paper processing aspect of contract management. But what happens once the time is saved? There could be a change in the size of the workforce, or in the nature of the organization, or in the nature of work. However, none of these changes are direct and immediate impacts of EDA.

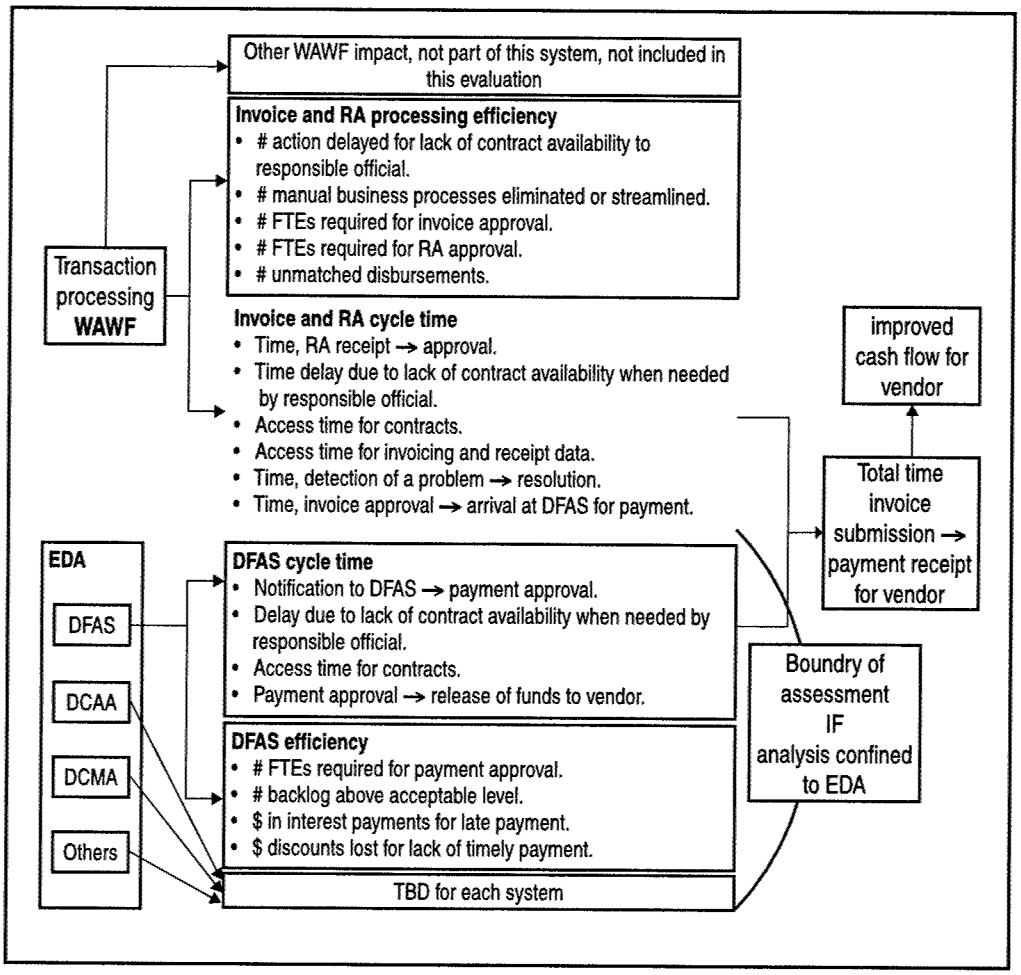


Figure 3. EDA – WAWF Interaction

In addition to the operation of outside forces, the impact of any single eBusiness system is constrained by interactions among multiple eBusiness systems. In any large organization, many different process improvements and eBusiness implementations are likely to be under way. Any single system is part of a larger developing infrastructure. Change in multiple parts of the infrastructure is needed to have truly profound impact. (Multiple systems are also the root of many methodological difficulties because evaluation requires teasing out the impact of one system from the combined impact of several.) The need to limit expectations for any single eBusiness system is illustrated by the relationship between EDA and WAWF.

One of our early logic models (Figure 3) took a very broad view of EDA. In doing so, it included the expected advent of WAWF, and it also took a longer-range view of likely outcomes. As Figure 3 shows, EDA alone can be expected to improve internal processing efficiency at DFAS. DFAS processing time, however, is only a part of the total cycle time from when a vendor submits an invoice, to the time payment is received. For the entire cycle time to be improved, WAWF would be needed to shorten many other cycle times that are part of the entire process.

CONCLUSION

It is difficult to evaluate the impact of eBusiness systems in real life operation because the data needed do not cleanly follow the contours of a system's application. This is true both organizationally and temporally. From an organizational point of view, existing data often cannot differentiate those parts of an organization that are using a system from those that are not. From a temporal point of view, data may not be available over time periods that will allow before and after comparisons to match a system's implementation schedule.

Many variations onthese themes exist, and many problems derive from these difficulties. For instance, useful data may be trapped in archaic systems. The definition of data elements may change over time. Because clean data cannot be found, multiple data sources are needed to triangulate on a conclusion, and the greater the number of data sources, the greater the likelihood of having to negotiate with recalcitrant data owners. Despite these problems, successful impact evaluation can be carried out, and guidelines — lessons learned — can be abstracted from past efforts that are applicable to future efforts. (To aid in this application, Table 5 summarizes critical issues.) We hope we have convinced the reader of this conclusion, and that by so doing, spurred further efforts at eBusiness system impact assessment.

"It is difficult to evaluate the impact of eBusiness systems in real life operation because the data needed do not cleanly follow the contours of a system's application."

Table 5. Critical Questions Within Lessons Learned

Critical Questions Within Lesson Learned
Metrics and data sources
What data are needed?
Who owns the data?
If data are not owned by group that commissioned the evaluation, can the necessary data be obtained?
Who/where are the few people who truly understand how needed data bases are constructed?
Can the data be extracted for the time period, and at the level of granularity, needed for the evaluation?
Are the data reliable?
Methodology
What comparisons can be made to determine the program's impact?
What are the specific targets (e.g. users, business processes) of each comparison?
What are the threats to validity for each comparison?
Program Logic
Who are the groups that must agree on what the system should be able to do?
What groups and business processes should be affected?
What are the proximate and secondary impacts?
What elements of a system must be in place before any particular impact can be manifest?
What are the key dependencies in the system and among impacts?
What are the time frames for particular impacts to appear?
Adaptive Systems
As a system becomes known, how does its availability affect decisions about what problems should be solved or opportunities pursued?
How is the business environment affecting beliefs about how a system should be used?
What new systems are being implemented that draw on the functionality of the system being evaluated?
As new uses of a system develop, which ones are important enough to be assessed?
Can evaluation tease out the contribution of one system from another?
Realistic Expectations
What are the critical claims for a system's value that must be measured?
What claims on their face are unlikely to occur?
What reasonable impacts were not originally envisioned for the program?
Interactions Among Lessons Learned
Does development of the evaluation methodolgy follow a "waterfall" of a "spiral" model?
Is there a process in place to detect how developments within one lesson category may affect the others?
Does the evaluation team have the expertise needed in qualitative and quantitative methods to integrate an evaluation approach across all lesson categotries?

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References

Argyres, S. N. (1999). The impact of information technology on coordination: Evidence from the B-2 "Stealth" Bomber. *Organization Science, 10*(2), 162–180.

Brynjolfsson, E., & Hitt, L. M. (1998). Beyond the productivity paradox. *Communications of the ACM,41*(8), 49–55.

Chan, Y. E. (2000). IT value: The great divide between qualitative and quantitative and individual and organizational measures. *Journal of Management Information Systems, 16*(4), 225–261.

Kaplan, R., & Norton, D. (1996). Using the balanced scorecard as a strategic management system. *Harvard Business Review, 74*(1), 75–85.

Macdonald S. (2002). The IT productivity paradox: Technological determinism masked my managerial method? *International Journal of Information Technology and Management, 1*(1), 1–29.

Malone, W. T., & Crowston, K. (1994). The interdisciplinary study of coordination. *ACM Computing Surveys, 26*(1), 87–119.

Mark, M. M., Henry, G. T., & Julnes, G. (2000). *Evaluation: An integrated framework for understanding, guiding, and improving policies and programs.* San Francisco: Jossey-Bass.

Martinsons, M., Davison, R., & Tse, D. (1999). The balanced scorecard: A foundation for the strategic management of information systems. *Decision Support Systems, 25*, 71–88.

Renger, R., & Titcomb, A. (2002). A three-step approach to teaching logic models. *The American Journal of Evaluation,* 23(4), 493–503.

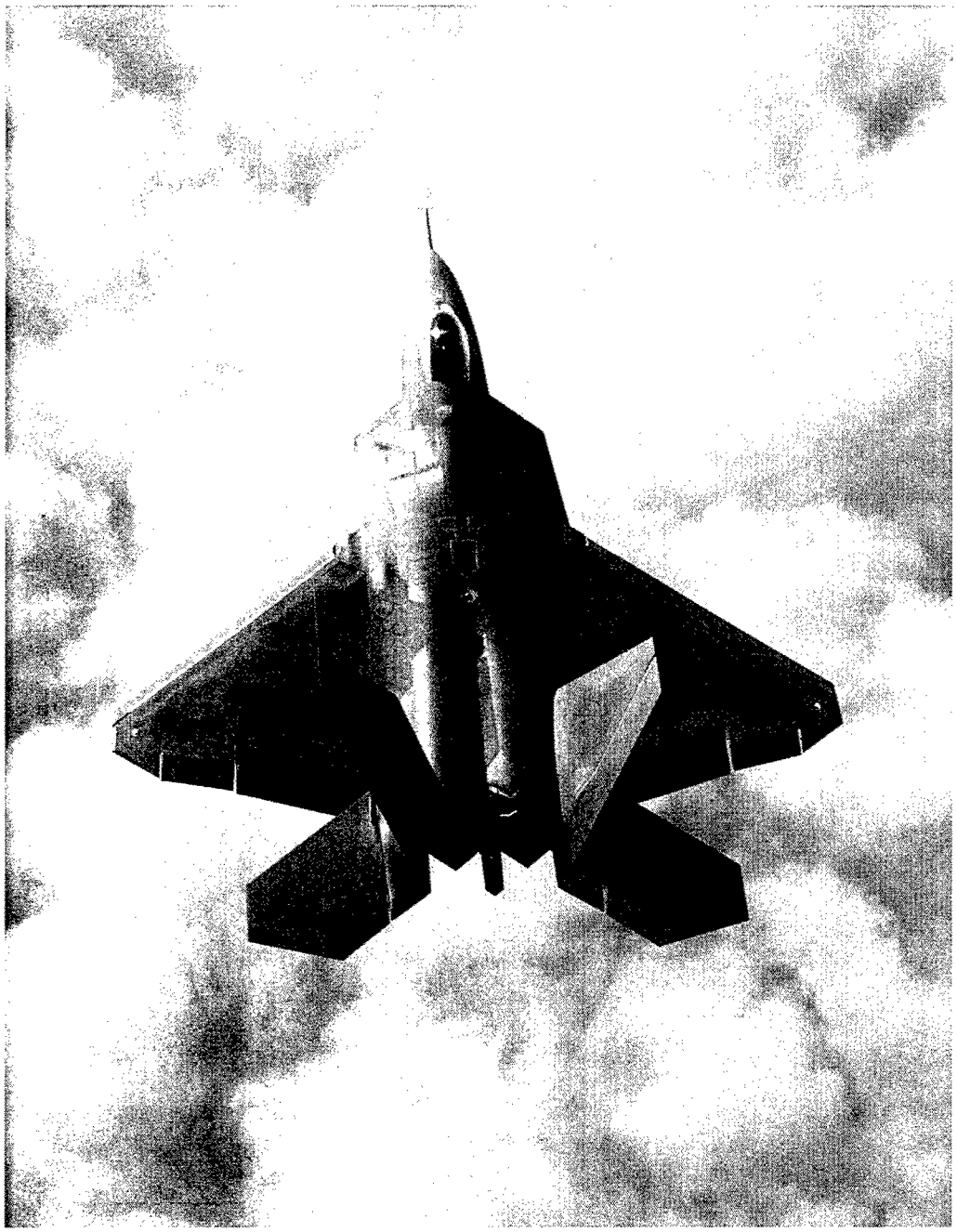
Rossi, P. H., Freeman, H. E., & Lipsey, M. W. (1999). *Evaluation: A systematic approach* (6th ed.). Thousand Oaks, CA: Sage Publications.

ENDNOTES

1. This article cannot serve as a complete treatment of measurement issues in evaluation. For a good introduction to this topic, see Rossi, Freeman, & Lipsey (1999).

2. As with the topic of measurement, this article cannot serve as a complete treatment of all-important issues in evaluation. For a good introduction, see Rossi, Freeman, & Lipsey (1999).

3. Balanced Scorecard in an organizational planning and assessment approach that casts leading and trailing indicators into four general categories: financial, customer, internal business process, and growth. It has been adapted for other contexts, but the principle of using measures from multiple domains is consistent. Diversity of measures is the Balanced Scorecard's greatest strength. When a single overriding metric is imposed on a system, the system will maximize that metric. Other crucial aspects of organizational functioning will be ignored, thus threatening the organization's long-term viability. The power of the Balanced Scorecard is that it helps organizations pursue the joint optimization of metrics that relate to different critical domains. For a general discussion of the Balanced Scorecard, see Kaplan and Norton, (1996). For a discussion of applying Balanced Scorecard to information systems, see Martinsons, Davison, and Tse (1999).



OPINION

HOW COMPENSATION IN TEST AND EVALUATION AFFECTS AIRCRAFT ACQUISITION

Lt Col Lionel D. Alford, USAF

Systems developers and testers have assumed that human compensation is measurable, or at least that a cognizant and trained tester is able to identify and detect compensation. More than one study conducted at the Wright-Patterson LAMARS facility indicates that this is not necessarily true. Test pilots were able to compensate sufficiently to fly and meet defined performance standards on intentionally crippled aircraft flight control designs. These flight control systems were designed to trigger pilot induced oscillations, but in most cases, test pilots could compensate sufficiently to prevent pilot induced oscillations and to control the simulated aircraft. Test pilot compensation hides critical handling qualities cliffs that can lead to loss of an aircraft when encountered by less skilled pilots. This observation has vast ramifications for test, evaluation, and development of all human interface systems.

After solving the problems of propulsion and lift, the control of an aircraft was the third and possibly greatest challenge the Wright Brothers faced in conquering the air (Figure 1). After all, the Wright Brothers really took eight years following their historic first flight to determine the problem of stall in a turn and how to correct it (Culick, 2001). They knew how to control the aircraft, but the controls were insufficient. The aircraft design, power, and stability were all factors in solving that problem.

Because aircraft design, power, and stability all affect and are affected by the aircraft control system, the key factor in the development of control systems for aircraft is to design them to optimize the aircraft performance while providing *carefree* handling qualities to the pilot. For example, the best fuel economy is achieved when the center of gravity is behind the center of lift. The center of lift is the neutral point of the aircraft and having the center of gravity at or behind the center of lift creates a condition where

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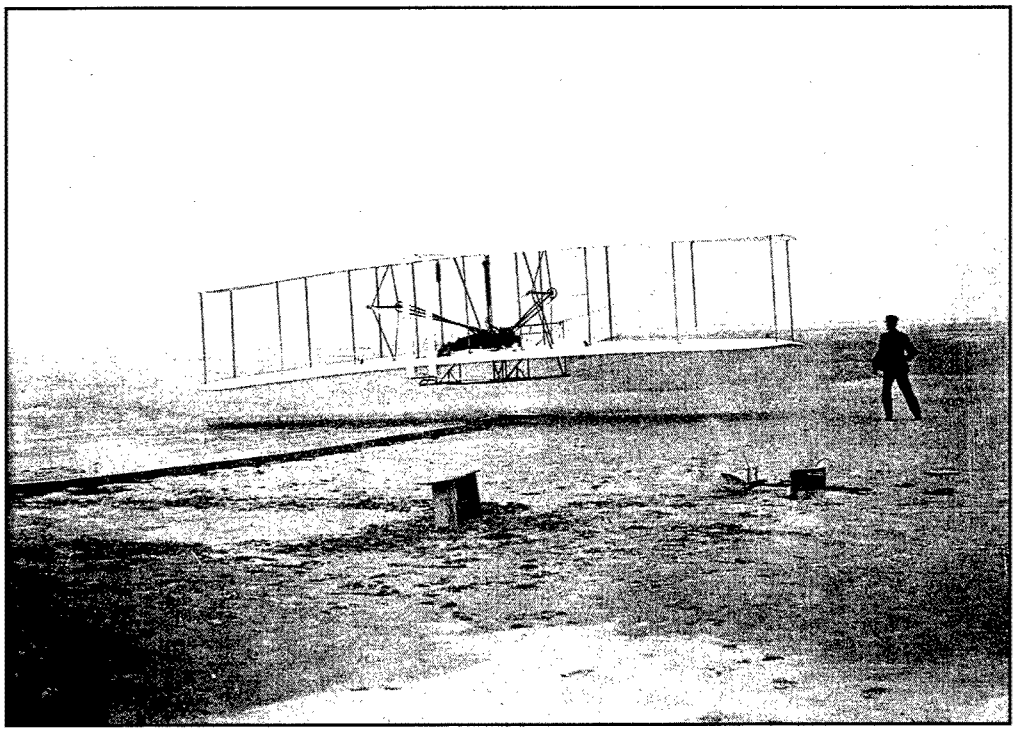

Figure 1. The Wright brother's first flight was still eight years away from a fully stable/controllable aircraft.

the aircraft is neutrally stable or unstable — both bad for handling qualities.

An aircraft can be designed with an electronic flight control system that gives the pilot a positive, stable, handling-qualities feel while the aircraft is unstable (Baer & Landy, 1987). This design results in increased fuel economy, a characteristic of the Airbus 320+ and the Boeing 777. Future airliners will certainly capitalize and expand on this capability. Another example of unstable aircraft design to achieve aircraft requirements is found in modern fighter-type aircraft. For radar stealth, maneuvering performance, and mission optimization, among other reasons, the exterior of military aircraft are designed in such a way that, without electronic flight controls, they would be unflyable (Rushby, 1993). The F-16, F-18, F-22, F-117, and B-2 are all examples of this type of design (Rushby, 1993).

The problem of aircraft handling exists because aircraft controls are counter-intuitive. Water and land-borne transportation turn using a device like a rudder to modify the velocity vector in the horizontal plane. This is an intuitive response that is easy to master. To turn an aircraft requires a roll in the horizontal plane coupled with a pitch rotation to counter loss of lift in the vertical plane and an increase in thrust to balance the increase in drag. The pitch rotation, and not the roll, turns the aircraft. A coordinated turn further requires a corrective yaw rotation in the horizontal plane to counter the slip induced by the original roll.

Aircraft motion is also characterized as a mass-spring-damper and therefore is a

system that responds in a manner significantly different than ground-based controls. The problem of aircraft control in thrust and pitch is further complicated by the power curve response in the region of reverse command where the pitch control largely directs airspeed and the thrust directs pitch — again an unintuitive response.

People can generally be trained to adequately control unintuitive systems such as aircraft. It should be self-evident that both ground and flight control systems represent natural phenomena that are within easy grasp of human beings. However, higher-order systems, those greater than second order, are not generally found in nature and may not be predictable by human beings (National Research Council, 1997; Rushby, 1993).

Modern digital flight control systems use approximations of mathematical equations that result in very high order systems to replicate the natural response of a non-electronically controlled aircraft. These systems of high-order approximations generally do a great job of reproducing the handling qualities of the perfect aircraft; however, they result in a system that potentially is unpredictable to the operator and they introduce unpredictable response in the overall aircraft system (National Research Council, 1997).

The problem of unpredictability of a flight control system is characterized by handling quality cliffs and pilot induced oscillation (PIO). A handling quality cliff is an unknown and untested area in a flight control envelope where it is possible for the pilot to unexpectedly lose control of the aircraft. A PIO is a situation where aircraft response lags the pilot's input to the controls. The pilot unconsciously increases control input such that each input magnifies the aircraft response until loss of control or the aircraft comes apart. PIO is not unique to digital flight control systems, but unforeseen PIOs are. These problems are best characterized by the distinctive mishaps they have spawned.

On October 26, 1977, the prototype Space Shuttle was launched from its 747 carrier aircraft. The pilots, Fred Haise and Gordon Fullerton, attempted a spot landing on the concrete main runway at Edwards Air Force Base. The shuttle had an electronic triply redundant digital fly-by-wire flight control system. The expected performance of the aircraft did not match the actual performance and Haise found himself too fast on the approach. His overcompensation resulted in a PIO in roll and pitch. In spite of this, he landed the shuttle safely (STS Approach and Landing Test, 1977; STS Space Shuttle, 1977).

"It should be self-evident that both ground and flight control systems represent natural phenomena that are within easy grasp of human beings."

NASA engineers found a 270-millisecond time delay in the flight control system that they corrected with a filter (STS Space Shuttle, 1977). In spite of this change, the pilot astronauts know the shuttle cannot be flown like a fighter.

The flight control system of the shuttle was based on and is similar to the F-16. The F-16 had and has a known 270-millisecond time delay in the pitch axis. If the aircraft is mishandled, this delay will result in a PIO, and PIO has been the focus of numerous mishap investigations (Rushby, 1993). The result is that pilots fly an F-16 approach and

landing like they would a heavy aircraft and not like a fighter.

Usually, critical PIO problems are only identified as a problem when they cause an aircraft mishap. On February 2, 1987 during its seventh flight, the first prototype Swedish Saab JAS39 Gripen crashed on landing. The Gripen had a triplex redundant fly-by-wire digital control system backed up by a triplex redundant analogue fly-by-wire control system. The first test pilot remarked that the flight control system was too sensitive and displayed problems with lateral and pitch oscillations. The pilot flying during the mishap had never flown the Gripen, and gusty wind conditions likely exacerbated the problems with lateral and pitch oscillations. The pilot encountered increasing PIOs characterized by dynamic pitch instability during approach. These control problems resulted in the aircraft striking a wing on landing and the destruction of the aircraft (Aviation Week, 1989; Flight International, 1989; Nutley, 1989; Pellebergs, 1991).

The Gripen program went through a very intensive flight and ground test program to fix the problems caused by the flight control system, and the aircraft continued development. Everything appeared fine until on August 8, 1993, during a normal maneuver, a pilot flying the Gripen in an airshow fully saturated the flight controls and entered an unrecoverable PIO. The manufacturer and the customer knew that large stick movements could saturate the flight control system, but the pilot was unaware of this aircraft characteristic. The aircraft was destroyed (Swedish Accident Investigation, 1993).

The Gripen is not the only aircraft that has experienced interaction of the pilot

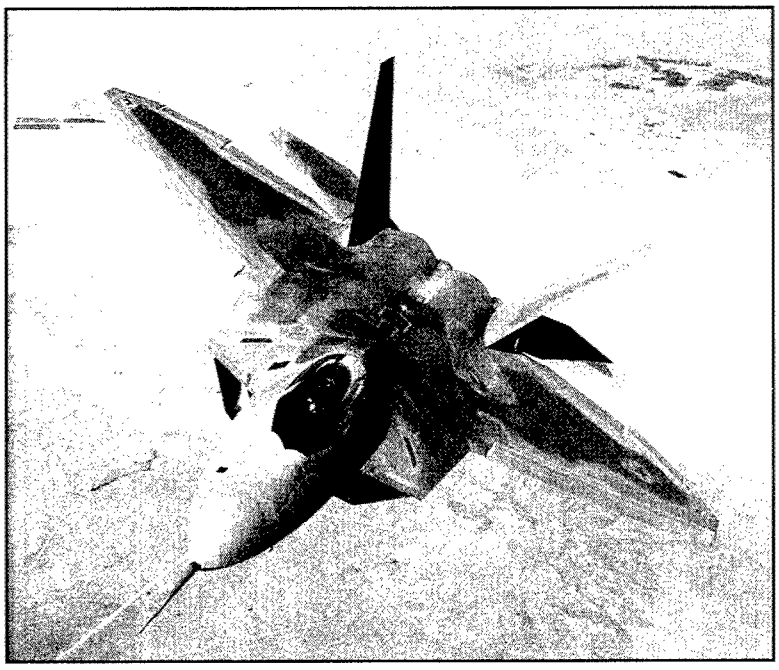

Figure 2. The latest F-22 loss of control incident is possibly a digital flight control cliff.

and the flight control system that resulted in the loss of a prototype aircraft. On April 25, 1992, the YF-22 (the production F-22 is shown in Figure 2) also crashed during landing due to PIO caused by the fly-by-wire system (Rushby, 1993).

Although PIO is a known problem of non-fly-by-wire flight control systems, time delays, handling qualities cliffs, unpredictable flight characteristics, saturated control systems, the attendant PIOs, and loss of control are characteristics of fly-by-wire flight control systems. One final example will illuminate this problem of PIOs as it relates to testing. Many of these control problems manifest themselves in the roll axis. In heavy aircraft, the problems result in a faster roll rate than normally expected (Norton, 1994). This unpredictability, combined with transport delays cause PIOs. The C-17 program encountered this problem late in its test program. The aircraft had a known quick roll rate, but test pilots who had been flying the aircraft for a while did not consider it a problem. New test pilots generally complained about the roll rate and its attendant PIO during landing approach, but they quickly learned to compensate. When a test pilot new to the C-17 recognized the problem and complained officially, the program blamed the pilot and continued with the control system unchanged. In Operational Test & Evaluation (OT&E), the operational pilots reported the problem as an aircraft deficiency and that is when it was finally fixed.

The difficulty in the C-17 program wasn't simply that a handling qualities problem existed in the roll axis. The problem was that so many trained test pilots, military and civilian, had flown an aircraft with an obvious deficiency and found it acceptable without changes. The factor of aptitude that allows trained test pilots to compensate for evident deficiencies in flight control system is the problem this paper directly addresses.

The Experiment

The above situations demonstrate that PIOs in fly-by-wire aircraft are neither uncommon nor insignificant, and they are more likely to be experienced by non-test pilot aviators. At best, they represent a nuisance and, at worst, a potentially catastrophic air event. Because of these problems, their criticality to flight and the danger of not finding them during developmental testing, we are studying PIOs, when possible, through simulations.

In December 1998, I participated as a subject in the HAVE LIMITS SIM and HAVE PIO SIM, PIO study conducted by the Air Force Research Laboratory Air Vehicle Directorate (AFRL/VA) that used the Large Amplitude Multi-Mode Aerospace Research Simulator (LAMARS). LAMARS is a 20-foot diameter sphere on the end of a 30-foot beam that comprises a 5-Degree of Freedom Simulator (Figure 3). The simulator includes a McFadden Feel System, wrap-around

"The factor of aptitude that allows trained test pilots to compensate for evident deficiencies in flight control system is the problem this paper directly addresses."

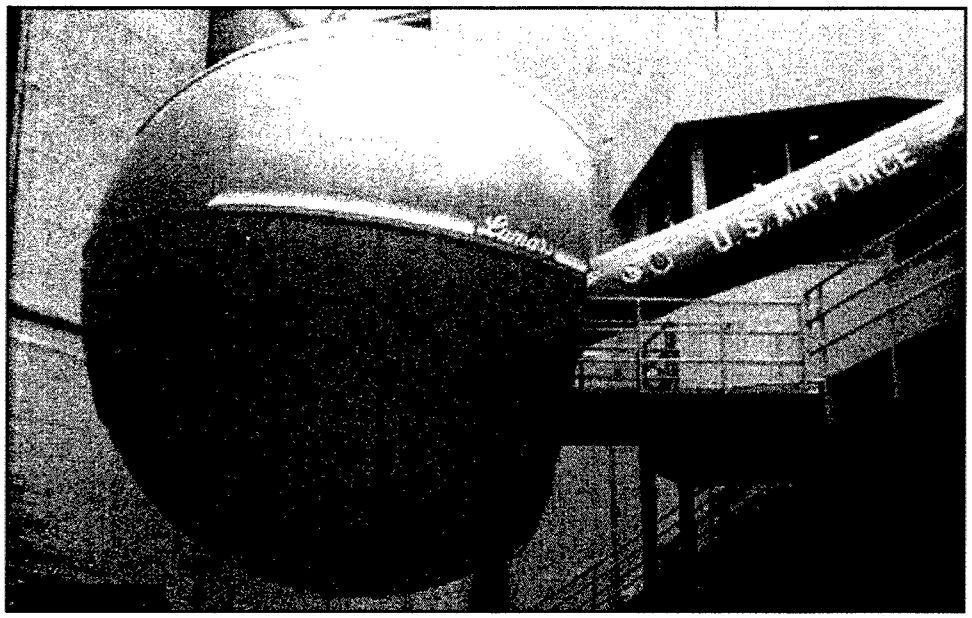

Figure 3. The LAMARS simulator

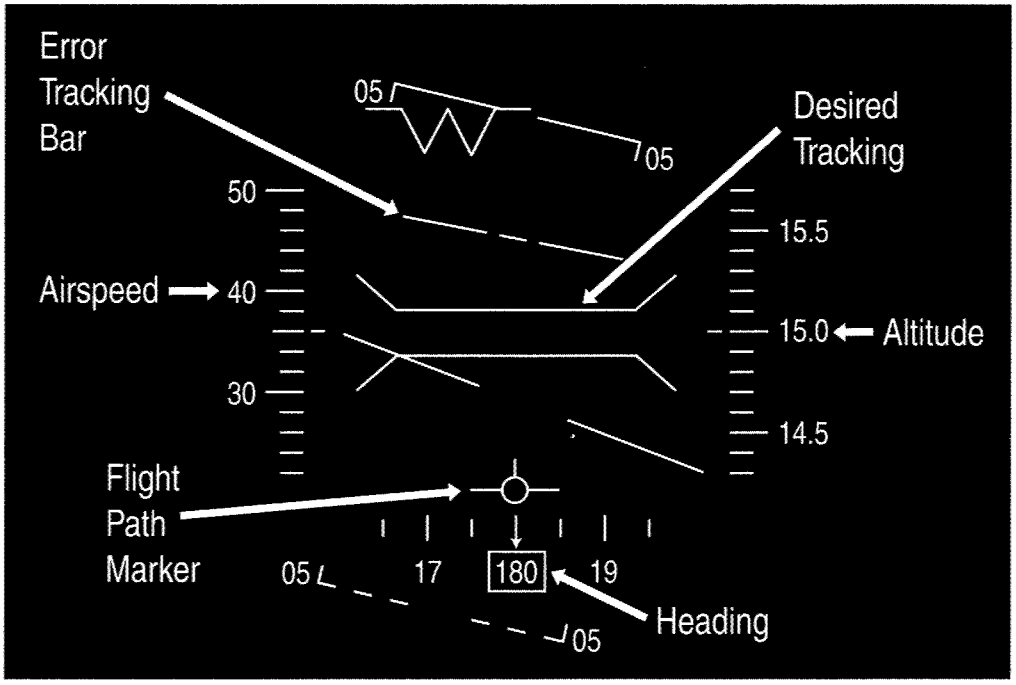

Figure 4. The heads-up display during the LAMARS test

visuals, and a Heads-Up Display (HUD) (Figure 4). The LAMARS system is capable of up to –2 to +3 g vertical and -3 to +3 g horizontal acceleration.

The purpose of the experiment was to gather data on aircraft handling qualities models (good, bad, and ugly) to correlate in-flight variable simulation data from the original HAVE LIMITS and HAVE PIO open air programs with simulation data. The experiment featured three pitch and roll capture tasks with increasing levels of workload and a landing task. The aircraft handling qualities models varied widely based on 18 variations tested previously in the CALSPAN/Veridian NT-33 variable stability aircraft. The study itself resulted in good data but simulation results could not be correlated with open-air flight test (Stadler, 1999). The observations I made came out of a deviation from the test and were not included directly in the test or research.

I had the opportunity to be the first of three test pilots who participated in the program. When I arrived to make the first runs, the LAMARS was not ready for motion. I flew a full set of the simulations as training without simulator motion. A few days later, I flew the remaining training and data runs with LAMARS accelerative motion. My observations come from the unique perspective of being able to see how the simulations flew with and without accelerative motion.

When the motion was off, some of the configurations were impossible to fly. Many of the flight control designs were divergent and resulted in complete loss of control. The simulator was relatively easy to PIO and many of the runs resulted in a departure from controlled flight. In most cases, the pilot could not respond quickly enough to go open loop when a PIO was immanent. Further, as reason might indicate, the higher the workload of the task the easier it was to depart the system. This was not true during the simulation runs with accelerative motion.

When accelerative motion was on, the tasks became easier to fly as the workload increased. Pilot compensation and learning occurred at a rate not possible without motion. Due to the natural feel in the acceleration, it was increasingly easy with increasing workload to maintain control of the aircraft. The pilot had to force himself to allow PIO conditions to continue. It was very easy to reduce workload slightly and allow the system to dampen out instead of pulling aggressively to the point that would have departed the system. This was very obvious with negative G during pushovers. Although, the simulations felt like they were often on the ragged edge of departure, it was possible to prevent a PIO and a departure. The feedback I received was that the departure rate overall during the study was lower than expected, "the bad was not as bad" as seen in the actual aircraft (Stadler, 1999). Additionally, the researchers observed that pilot anticipation of the PIOs may have skewed the data.

"When accelerative motion was on, the tasks became easier to fly as the workload increased."

It would be easy at this point to conclude that the study itself did not provide much useful data, but I think this

program highlighted a very critical area that has not been considered much in flight testing — test pilots may not be able to gauge how much they are compensating.

RESULTS

The observation that *test pilots may not be able to gauge how much they are compensating* is not as obvious as it seems. We expect average pilot subjects to not know they are compensating — we assume they are compensating and we assume we can measure that compensation through workload. For test pilots the situation is different. A key skill in which we train test pilots is to observe and know when they are compensating. This is the proverbial test pilot *handshake*. If test pilots cannot gauge their compensation, then there is little hope of solving the critical problems that face us in digital flight control systems. Indeed, based on this observation, we may have to look for a different way of designing and testing not just flight control systems but all types of human-machine interfaces.

"Acquiring firms consider both distressed and highly profitable firms as potential acquisition candidates."

As long as the aircraft is predictable, and predictability increases dramatically with natural accelerative motion, the pilot can apply reflexive filtering that normally prevents PIO and departure. As my experience in the simulator with and without accelerative motion demonstrates, without accelerative motion, the system is not as predictable as with accelerative motion. Without G force, the system is less predictable. The aircraft's acceleration makes possible *heroic response* to bad flight control systems.

I assert *heroic response* with intended experimental precision. Heroic response is exactly what any pilot accomplishes when faced with a poor flight control system design. Experienced pilots unconsciously feel the natural/predictable modes of an aircraft and successfully compensate for poor handling qualities. Most pilots do not realize the degree of compensation used to counteract normal aircraft handling qualities.

In an aircraft development program, as an aircraft flight control system improves, the test pilot's compensation improves and without a significant event, such as a recalibration of the pilot's compensation experience, the compensation will continue to improve. As with the C-17 example, and much of my flight test experience shows, test pilots, like all pilots, will at some point no longer be able to gauge their compensation and then they will not be of much use to the test program. Without training or comparisons, it may be impossible for pilots to gauge the degree of compensation, especially with long-term programs and programs where handling qualities have improved gradually over time.

This observation is true of flight control systems as well as any other control system in an aircraft. I further suspect that this observation concerning compensation and test pilots is true of tests in all other complex systems.

In the case of unnatural or unpredictable modes of digital flight control aircraft, these modes can only be learned through experience — if undiscovered and uncorrected, these handling qualities *cliffs* will result in loss of aircraft. These characteristics of pilot compensation make digital flight control aircraft more difficult to sufficiently test.

Pilots may learn to compensate to the degree that they unconsciously filter even unnatural and unpredictable modes. However, if the mode is not experienced, is unpredictable, or is not discovered and corrected during testing, some operational pilot will eventually encounter a handlings quality cliff, and recovery may not be possible.

Recommendations

1. More research needs to be accomplished on measuring pilot compensation — and workload may not be a good measure. Workload measurement has been the *Holy Grail* of human factors testing. To date we do not have a quantitative measure of workload and this makes human factors testing subjective and difficult. Quantitative workload measurement is a needed and necessary tool for human-machine interface development, but there is a piece of the puzzle that is still missing in workload measurement — how do we quantify compensation?

2. Test pilots require hands-on training to understand the level of compensation possible during test programs. The LAMARS facility with its PIO models provides an excellent means of training. This training should be required in every Test Pilot School curriculum and taught as continuing Test Pilot education. Prior to the test of digital flight control system aircraft, the pilots on the program should attend some level of refresher orientation. The training should allow the comparison between *seat-of-the-pants* accelerative motion and no-motion to drive home the point that too much exposure to bad flight control models skews the pilot's perspective, and a pilot can become too comfortable with a poor flying system.

3. Test pilots need to constantly recalibrate their awareness of aircraft handling quality differences and compensation. The best way to achieve this is through multiple qualifications and qualification flights in different aircraft. All programs could benefit from this regimen. Test pilots who don't fly multiple aircraft and who cannot compare different designs and systems lose the ability to identify their level of compensation. The best method to keeping this critical skill sharp is to experience known deficient designs and poor handling aircraft. Test pilot schools and test centers should ensure a large number of poor aircraft and historical aircraft are available for test pilot qualification. The services should address this problem by allowing test pilot access to more systems.

4. An obvious but often overlooked recommendation in the analysis of fly-by-wire systems is that developers should attempt to design predictable flight models that don't just mimic natural aircraft response but truly match it.

Conclusion

We may have underestimated the role of compensation in testing and we need to determine ways to measure compensation. Pilots can learn to adequately fly poor aircraft with intentionally poor handling qualities. They appear to be able to unconsciously filter certain characteristics in the handling

qualities envelope of the aircraft. Unfortunately, systems developers and testers have always assumed that human compensation is measurable, or at least that a cognizant and trained tester is able to identify and detect compensation. The HAVE LIMITS SIM and HAVE PIO SIM studies conducted at the Wright-Patterson LAMARS facility indicate that this is not necessarily true. Test pilots were able to compensate sufficiently to fly and meet defined performance standards on intentionally crippled aircraft flight control designs. This creates critical questions for the testing of future human interface system. To help solve these problems:

- More research needs to be accomplished on measuring pilot compensation.
- Test pilots require hands-on training to understand the level of compensation possible during test programs.
- Test pilots need to constantly recalibrate their awareness of aircraft handling quality differences and compensation.
- Developers should attempt to design predictable flight models that don't just mimic natural aircraft response but truly match it.

Digital control systems create unique problems for engineering design and flight. In the case of aircraft, the best design approach may be to develop predictable flight models that directly match or simply augment natural aircraft response instead of using complex digital equations that imitate assumed aircraft response. Until that point is reached and because of the difficulties involved in designing human interfaces and the human control of complex systems, we must find quantitative ways to measure compensation and we must control experiments to address compensation issues.

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BIBLIOGRAPHY

A330 accident preliminary report summary. (1994). *Air et Cosmos, 1482.*

A330 accident preliminary-Preliminary findings from the telemetry data. (1994). *Air et Cosmos, 1480.*

Angner, J., Jensen, C., & Seidl, M. (1996). JAS 39 Gripen EFCS: How to deal with rate limiting. *SETP 40 Symposium Proceedings.*

Beatson, J. (1989, April 2). Is America ready to "Fly by Wire"? *The Washington Post*, p. C3.

Gerner, A., & Manning, M. (1991). Frequency response analysis and modified maximum likelihood estimation of a T-38A. Edwards AFB, CA: USAFTPS.

Moss, C., & Shifflett, S. (1997). B-2A Residual Pitch Oscillation (RPO) investigation. *SETP 41 Symposium Proceedings,* Edwards AFB, CA: 420 Flight Test Squadron.

References

Baer-Riedhart, J., & Landy, R. (1987). Highly integrated digital electronic control — digital flight control, aircraft model identification, and adaptive engine control. NASA Technical Memorandum 86793. Edwards AFB, CA: NASA Ames Research Center, Dryden Flight Research Facility.

Staff. (1989, February 27). Saab blames Gripen crash on software. (1989, February 27). *Aviation Week & Space Technology*, 130 (9), 31.

Culick, F. E. C. (2001). Wright brothers: First aeronautical engineers and test pilots. California Institute of Technology: *SETP 45 Symposium Proceedings*. Retrieved December 30, 2003 from http://www.wrightflyer.org/Papers/SETP01_Culick.pdf

Department of Defense, Defense Management Review. (1989, July). Defense management: Report to the President. Secretary of Defense, Richard Cheney. Retrieved February 29, 2004 from http://www.defenselink.mil/nii/bpr/bpred/289a.htm

National Research Council. (1997). Aviation safety and pilot control: Understanding and preventing unfavorable pilot-vehicle interactions. National Academy Press. Washington, D.C.

Norton, W. J., & Melroy, P. A. (1994). C-17A airloads flight tests. *SETP 38 Symposium Proceedings,* Edwards AFB, CA: 412 Test Wing, Air Force Flight Test Center.

Nutley, M. (April 3, 1989). "Swedish wind cuts fly-by-wires." Datalink (a British paper for system software). Retrieved March 3, 2004 from http://catless.ncl.ac.uk/Risks/8.49.html

Pellebergs, P., & Lindholm, A. (1991). JAS 39 Gripen flight test report. *SETP 35 Symposium Proceedings.* SAAB-Scania AB, Aircraft Division.

Rushby, J. (1993, November). Anomalies in digital flight control systems (DFCS): SRI international computer science laboratory. Report SRI-CSL-93-07.

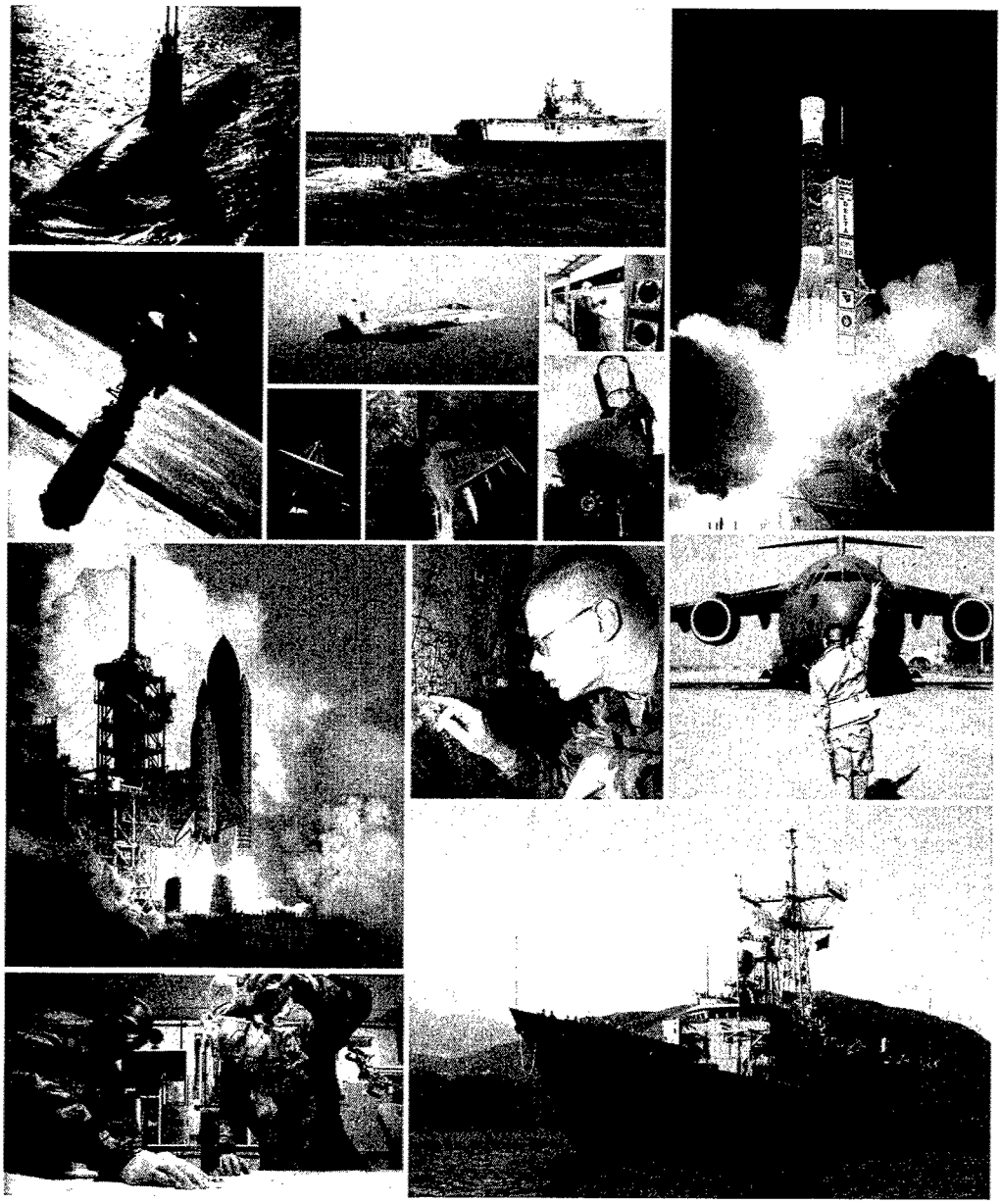
Stadler, B. (1999). Recommendations to improve future pilot-induced oscillation simulations. Wright-Patterson AFB, OH: AFRL/VACD.

STS Approach and Landing Test (ALT). (1977, February). First Shuttle/747 captive flight. Retrieved December 29, 2003 from http://www.dfrc.nasa.gov/gallery/photo/ALT/HTML/ECN-6887.html

STS Space Shuttle. (1977). STS approach and landing test (ALT): Flight 5 — pilot-induced oscillation (PIO) on landing: Movie Collection. Retrieved December 29, 2003 from http://www.dfrc.nasa.gov/gallery/movie/STS/HTML/EM-0043-02.html

Swedish Accident Investigation. (1993). The Swedish accident investigation boards report summary. JAS 39 Gripen crash in Stockholm 1993 Aug 08 report summary. Retrieved December 30, 2003 from http://www.canit. se/~griffon/aviation/text/gripcras.htm

Gripen crash caused by flight control softwarefighter crash. (1989, March 25). *Flight International*. Retrieved March 3, 2004 from http://catless.ncl.ac.uk/Risks/8.49.html



A TEN-YEAR REVIEW OF THE VISION FOR TRANSFORMING THE DEFENSE ACQUISITION SYSTEM

Edward W. Rogers, Ph.D. and Col. Robert P. Birmingham, USA (Ret)

"With this report, then, we begin a decade-long process of reinvention."

"We hope it will transform the habits, culture, and performance of all federal organizations."

(Former Vice President Al Gore, 1993)

This paper traces the vision for reform of the Department of Defense Acquisition System from 1993 through 2003. Using a qualitative document review process, a conceptual picture of overarching themes is presented. The purpose of this paper is to provide an analysis of the change roadmap to assist building empirical research models of the effectiveness of the various initiatives, programs restructurings, and policy mandates that have all contributed to the current climate for change within the DoD and the acquisition community.

The year 2003 marks the end of a decade of concerted effort at transforming the way the government does business. A major focus of that effort has been the transformation of the way the Department of Defense (DoD) acquires new equipment through the Defense Acquisition System. In fact, the beginnings of this journal were steeped in acquisition reform. The topic has been an on-going subject with six or more articles per year dealing with acquisition reform efforts. The inaugural issue in 1994 opened with a piece by then Deputy Under Secretary for Defense (DUSD) Colleen Preston outlining the new initiatives for acquisition reform (Preston, 1994). The pages of the *Acquisition Review*

DISCLAIMER

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Quarterly have proven to be a forum for a fertile debate on the merits, means, and misgivings of acquisition reform. This article looks back over the last ten years and traces the path of the vision for that change.

In 1993, the National Performance Review (NPR), released under then Vice President Gore, laid out a vision for change that many have considered the landmark for a new decade of effort to change the way the government does business. This paper attempts to take a conceptual view of what evolved from that NPR mandate into the particular vision for changing the Defense Acquisition System within the DoD (Gore, 1993). What makes this a good time for reflection is the fact that near the end of 2002, the Deputy Secretary of Defense, Paul Wolfowitz issued a memorandum canceling the DoD 5000 series of acquisition policy documents (Wolfowitz, 2002).

"The purpose of these interviews was not to collect a sample of data but to clarify the understanding of the documents and the intent of the some of the terms, titles, and statements to avoid misinterpreting the written records."

Deputy Secretary Wolfowitz judged the latest documents to be "not conducive to an acquisition environment that fosters flexibility, efficiency, creativity, and innovation." This raises the question of what exactly happened to the vision for acquisition reform during the past decade. To answer this question the authors of this paper decided to bring together their respective academic knowledge of organizational change and the practical experience of program management to examine a decade of reform effort.

Methodology

We conducted a broad review of literature on reform of the DoD to identify key documents that could be considered landmarks or mandates for the acquisition transformation process. We searched government documents available on-line as well as those suggested by talking with people working in the acquisition corps. We also reviewed published articles in the *Acquisition Review Quarterly* since its inaugural issue in 1994. From a total of several hundred documents collected and examined, we selected seven as dealing broadly with a vision for changing the acquisition system.

In addition to the document search, interviews were conducted with a number of individuals in the Pentagon, the acquisition community, program managers, and industry leaders. The purpose of these interviews was not to collect a sample of data but to clarify the understanding of the documents and the intent of the some of the terms, titles, and statements to avoid misinterpreting the written records. We also used the interviews to confirm that we had selected what people involved in defense acquisition generally consider the landmark documents that have set the direction of change during the decade. Since the overall purpose of the report was very broad we agreed to a complete non-attribution arrangement with all the people interviewed.

We distilled the contents of the seven documents into tables highlighting their key elements for ease of comparison. From the summarized tables and interviews, we traced the evolution of the different aspects of the overall vision for change including the drivers (perceived problems), and the description of the desired end state. From our analysis of key milestone documents we developed a conceptual picture of how the transformation vision has evolved over the decade. Finally, we propose several observations that should be addressed with empirical methods to help answer important policy questions regarding acquisition reform. We hope this review effort will help spawn research and debate for charting the way towards a new and better acquisition system for the DoD.

The National Performance Review — 1993

The decade beginning in 1993 certainly was not isolated from the previous decades and prior attempts at reforming the DoD. David Packard had a large influence on the reform movement starting with the Packard Initiatives in 1969 through the Packard Commission and its report, "The Quest for Excellence" delivered in 1986. This era closed with Secretary of Defense, Dick Cheney's "Defense Management: A Report to the President" in 1989. These efforts attempted to deal with ballooning costs, duplicative programs across services, and the authority lines for determining acquisition priorities, budgets, and program evaluations but often also added layers of reporting and bureaucracy. This led Thomas McNaugher to lament at the end of the 1980s that the defense acquisition system may actually be worse for the reform efforts of that decade (McNaugher, 1990).

Without ignoring the impact of prior efforts, we limit this review to the decade that began on September 7, 1993 when Vice President Al Gore released his landmark report: "Creating a Government that Works Better and Costs Less: The Gore Report on Reinventing Government" as part of the NPR. While the Gore Report primarily focused on government waste and inefficiency, elements of the report impacted efforts at transforming the way the government conducts the business of defending the country as well. While the Gore report only mentioned three things directly related to acquisition reform, the fact that the Office of the Vice President was behind the concepts carried considerable weight. As related to defense, the Gore Report called for a need to 1) simplify procurement, 2) eliminate regulatory burden and 3) rely more on the commercial marketplace. These goals spoke of a need to change the culture of how the government conducts the business of defense.

"The decade beginning in 1993 certainly was not isolated from the previous decades and prior attempts at reforming the Department of Defense."

The key theme of the NPR was that government was broken and the system needed to be overhauled from the top to the bottom to regain effectiveness. After the release of the NPR, many people in the government bureaucracy faced uncertainty about just how the government would function in the future. Such a broad

change mandate coming from such a high level created a sense of imminent change. In response, many departments began to develop change programs including the DoD and its new Secretary, William Perry. The release of the NPR was quickly followed by a document outlining how and why change was needed within the DoD.

A Mandate for Change: The Perry Memo — 1994

On February 9, 1994, six days after being confirmed as Secretary of Defense William Perry released a memo titled, "A Mandate for Change" calling for a complete cultural change in how the DoD operates. Budgetary and efficiency issues remained important guiding principles drawing from the NPR, but the focus shifted from processes to outcomes (capability in the field). The main directives of the Perry Memo were based upon themes in the NPR. First, he called for a cultural change pointing out that the systems themselves were dysfunctional. Second, the outcomes were not effective (primarily too slow). Third, the obstacles to change were mostly internal (bureaucratic inertia). Secretary Perry clarified the essence of the need for change in his memo and created the sense of urgency that required immediate action. It also became clear that the DoD was not exempt from the NPR mandated transformation effort in the Federal Government.

"If the NPR showed what was wrong with government, then the Perry Memo demonstrated what was wrong with the DoD and why it had to be changed now."

If the NPR showed what was wrong with government, then the Perry Memo demonstrated what was wrong with the DoD and why it had to be changed now. With many examples (following the NPR format), Secretary Perry carefully built an argument to show the failure of existing systems to deliver effective solutions to the warfighters. In particular he noted the threat of a reduced defense industrial capability in the post–Cold War era. In response to the challenge laid out by Secretary Perry, an office was created to specifically deal with transformation issues and to ensure that change was made in an effective way.

Acquisition Reform under the DUSD (AR) Colleen Preston — 1995–97

After the Perry Mandate in 1994, a special office of Deputy Under Secretary for Defense (Acquisition Reform) (DUSD[AR]) was established with Colleen Preston the first office holder. Her vision for change was based heavily upon events at the time including the recent passage of the Federal Acquisition Streamlining Act of 1993 (FASA). The formation of the AR office was a strong signal to the acquisition community that change was coming as a result of the Perry Memo. Colleen Preston became a spokesperson writing articles in the *Acquisition Review Quarterly* (Preston, 1994), testifying before Congress (Preston, 1995a), and appearing in other DoD publications (Preston, 1995b).

Her mandate was to find ways to address the declining industrial capability while improving system responsiveness and reducing costs again echoing the main drivers of the Perry transformation vision. It thus was a mandate for both increased efficiency and effectiveness while restructuring the industry-government relationship base.

This was obviously a daunting task especially given the size and inertia of the defense industry and the acquisition community in general. DUSD(AR) Preston set out to build a specific change vision around the elements of the Perry Memo by importing best practices from the business world.

Three specific initiatives probably best characterize her efforts: the implementation of Process Action Teams (PAT), the adoption of Integrated Product Teams (IPT), and efforts made to capture lessons learned within the DoD and the acquisition change process itself. All three of these have endured within the broader acquisition community as acceptable methods of operation throughout the decade.

A major focus was directed toward rewriting the DoD Directive 5000.1 and the DoD Instruction 5000.2 documents. At the same time, a project was started for creating desktop PC accessible tools for disseminating the new policies to the acquisition community. This effort involved collecting best practices, success stories, lessons learned, and communicating them as widely as possible across the acquisition community. Practices were identified and borrowed from industry in an effort to reduce lead time and cost in getting state-of-the-art technology into the hands of warfighters. A key component of this approach involved using commercial suppliers rather than defense-only suppliers to take advantage of the relaxation of military specifications (MILSPECs) and the policy implications of the Federal Acquisition Streamlining Act (FASA). This implied further shifts in the defense industrial base requiring fundamental changes in the contracting relationship between the government and its key suppliers.

Defense Reform Initiative — Cohen 1997–99

At the end of 1997, acquisition reform efforts were centered in an office called the Defense Reform Initiative (DRI). Secretary of Defense William Cohen in the DRI Report in November 1997 reiterated the vision and urgency of continuing to reform the way the DoD conducted business. The key assumption of the report was that under constrained resources and new threats, existing resources must be "reallocated from overhead and support activities to our fighting forces." DRI also took on the task of achieving a "Revolution in Business Affairs (RBA) to support the Revolution in Military Affairs (RMA) already underway" (Defense Reform Initiative [DRI] Report, 1997, p. ii).

> Reducing overhead and support structures by bringing the revolution in business affairs to DoD will be critical to achieving the revolution in military affairs. (DRI Report, 1997, p. ii).

The transformation of the military was driven by the guidance in the *Joint Vision 2010* document that outlined how the future military forces will defend the country. A central element of that vision is maintaining a superior ability to flow information from and to the battlefield. This information flow capability struck a chord with the acquisition community because the bureaucratic jams described in the NPR and the Perry Memo pointed out that it was the supply and support services that were slowing down the military's responsive capability. The new threats would not allow for this slack in the support system. The acquisition and

support activities must be brought up to speed with the technology and information flows to the field.

This vision of a *back-office* transformation to support the field operations became an identifiable link between acquisition reform and military effectiveness. This pointed connection may have been much more actionable than the more general *government is broken* mantra of the NPR and Perry Memo. While a boost to the sense of urgency, the vision also took on a programmatic focus in the sense that the goal of reform became shortening the technology development cycle time, speeding field delivery, and doing both at a lower cost. For example, the 5000 rewrite became a top priority and the implementation of cost-saving processes the critical tasks. In the midst of this process improvement the focus on fundamental cultural change diminished.

"Of the many policy and structural changes made, the Defense Management Council (DMC) was one of the most significant."

Of the many policy and structural changes made, the Defense Management Council (DMC) was one of the most significant. By appointing a high level group representing all of the services, the intent was to bring focus and momentum to the change efforts. The decision read as follows: "Establish a Defense Management Council (DMC) to serve as the Board of Directors for the Defense Agencies and to oversee the continued reengineering of DoD." (DRI Report, 1997, p. 19). The goal was to get senior leadership involved in the change process thereby circumventing bureaucratic inertia and resistance to change inherent in any large organization.

While it is clear that change must be supported at the top, the momentum for change may not have increased with the addition of the DMC as a monitor of reform. Being a representative body, it may have had a built-in bias for protecting the status quo rather than advocating change.

The Road Ahead — 1999 (2000) Gansler DUSD (AT&L)

The next major direction change came in 1999 with the issuance of a document called *The Road Ahead: Accelerating the Transformation of Department of Defense Acquisition and Logistics Processes and Practices*[1] (Gansler, 2000). This document laid out the framework for the Revolution in Business Affairs (RBA) to support the term Revolution in Military Affairs (RMA).

The RMA set out objectives that would have to be met in order to ensure military success against future threats and enemies. The RBA was meant as a way of stating that delivery to the field required a different management of the acquisition and logistics supply chain behind the new military. The message was clear: If the military had to change to meet new threats, the support system had to change to supply the new military.

The DRI's vision documented in *The Road Ahead* clearly shows an overall *faster/cheaper* simplification of the transformation mandate. There was much more emphasis placed on *cost* issues and less focus on cultural change of the bureaucracy. The three goals were 1) faster (reduce average acquisition cycle time), 2) cheaper (lower total ownership cost in program costs and logistics support), and 3) cheaper (lower overhead costs of acquisition and logistics).

Even though the argument of cultural change and defense industrial base sustainment had faded, this document was widely circulated and quoted as the new direction for maintaining the change momentum. This document brought the full force of the change effort to bear on reducing costs in the bureaucracy thereby freeing up funds and time to improve deployment to the field. The document gave impetus to the further use of commercial techniques and to a greater use of outcome driven performance improvements. This meant more performance-based contracts, commercial business practices and flexible responsibility at the program management level.

These changes had a profound impact on major acquisition programs such as the RAH-66. From the first contract award after gaining approval to proceed into Demonstration and Validation (MS I) in 1991, the RAH-66 Comanche Program underwent a series of directed restructures as DoD priorities shifted during this reform decade. With each restructure, the entire program's Training and Doctorate Command (TRADOC) approved requirement and contract went under review and updating. Accommodating the changing acquisition environment, from MILSPECs to commercial standards coupled with a greater reliance on performance based contractual agreements, each restructure adopted, or was forced to adopt, the new acquisition reform initiatives.

One perhaps unintended result was that the full responsibility for total system integration via performance standards migrated to the contractor resulting in the perception that the government Program Management Office (PMO) performed little more than contractual oversight via participation in the IPT process. The paradigm of risk ownership migrated away from the contractor from the Lehman Years Fixed Price Research and Development (R&D) contracting methods where the burden of program risk rested primarily with the contractor. During Pete Aldridge's tenure as Defense Acquisition Executive (DAE), he continued the transition of risk from the contractor to the government by formally emphasizing that the burden of risk in the execution of complex development and integration programs will be placed squarely on the shoulders of the government.

"Achieving Key Performance Parameters (KPPs) was no longer a decision of which engine, gun, or rotor system but how much shaft horsepower, how many rounds per minute, and what rate of climb."

Achieving Key Performance Parameters (KPPs) was no longer a decision of which engine, gun, or rotor system; but how much shaft horsepower, how many rounds per minute, and what rate of climb. For example, the initial weight and cost goals for Comanche as directed from then Army Acquisition Executive (AAE) James Ambrose in 1987, was for Comanche to weigh no more than 7,500 pounds and cost no more than $7.5 million per aircraft. Although noble goals, they were not performance-based objectives. However, regardless of the acquisition reform methods, these two goals continue to haunt the program as measures of how much the aircraft performance has changed and degraded over time. This raises an important reform question of which standards will be used

to measure reform progress? These issues demonstrate the need for clear vision of the end state, not just the savings or speed that the process changes hope to achieve. What is the vision for how weapons systems will be acquired in the future? How will programs currently in the pipeline be measured when they were started under one system, modified numerous times as the Comanche was, and perhaps finished under a third acquisition environment?

The Road Ahead was also the launching document for the third reform program office under the auspices of the DUSD Acquisition, Technology and Logistics (AT&L) Pete Aldridge called the Office of Acquisition Initiatives (AI). The AI office continued to work through 2002 on a number of initiatives, the major one being to rewrite the 5000 series of documents guiding acquisition policy. Other efforts included a new guide to managing intellectual property, program risk management, and contracting tools (cost as an independent variable, earned value management and performance base contracting, etc.). The Office of the Secretary of Defense (OSD) AI worked to document reform progress and cost savings. The office also worked hard to get the new information disseminated to the acquisition community. A desktop reference was put together allowing on line access to many of the policy and guide materials for acquisition.

"Faced with a growing list of prescriptive compliance items to document adherence to reform, some program managers began to view these reform efforts as burdens rather than process improvements."

The Defense Acquisition University (DAU) was reorganized and decentralized into five regional campuses to get closer to the customers. Many of the 5000 changes appeared as new directives for program managers' compliance. Faced with a growing list of prescriptive compliance items to document adherence to reform, some program managers began to view these reform efforts as burdens rather than process improvements. Realizing the reform cycle had come full circle to where it was creating the additional paperwork it was supposed to eliminate might have contributed to some of the cynicism toward acquisition reform in the program offices during this later part of the nineties.

For example, the burden to accommodate the best practices in measuring earned value of work performed within the confines of a large R&D program was particularly difficult as more and more contracts were awarded to partnerships and Joint Ventures. Few realized how difficult a task it would be to merge two completely different cost accounting paradigms into a single Earned Value Management System (EVMS) document. For Comanche and other large complex, and long running programs, the process was even more complex as the mergers and acquisitions of major Defense contractors brought the entire DoD helicopter industry dangerously close in terms of labor and overhead rates.

Additionally, as Comanche underwent a series of four major restructures throughout the 1990s, measuring earned value from a realistic and established baseline was seldom more than a two-year event. It was no surprise that Boeing and Sikorsky enjoyed EVMS metrics, which seldom deviated from 1 over a

ten-year period. It was not until the MS II contract award that the EVMS data being reported indicated that neither contractor could keep up with the planned work of funding. Although criticized for often shifting the baseline work, the EVMS process implemented by the Comanche contractors provided a clear picture as to how far behind schedule and over budget the program was headed just six months after the contract was awarded in 2001.

During the most recent restructure of Comanche, the Program Manager enforced contractual requirements for the Joint Venture to implement an integrated management plan that accommodated differences in manpower loading, overtime rates, and labor rates across the two companies to reflect more accurate and timely EVMS information. These are examples of how reform efforts often require more attention than imagined to implement and have consequences in industry, labor, and commercial markets that affect the outcome of initiatives.

Rumsfeld's Vision — September 10, 2001

The events of September 11, 2001 raised dramatically the urgency of solving acquisition problems. Ironically, on September 10, 2001, Secretary of Defense Donald Rumsfeld delivered a key speech outlining his determination to *liberate the Pentagon from itself* by reducing bureaucracy and simplifying the acquisition process. This document laid out the new secretary's vision for building the future military and the defense system to support it. The *system* was the enemy and needed to be defeated. "The topic today is an adversary that poses a threat, a serious threat, to the security of the United States of America. It's the Pentagon bureaucracy" (Rumsfeld, 2001). The unfortunate events of the next day undoubtedly lessened the impact of these words on the change process. However, they still are evidence of the intent, vision, and determination to transform the acquisition system.

Rumsfeld's vision contained several key elements. Notably he again emphasized the concept of commercial outsourcing to save money and a renewed emphasis on doing only the functions directly related to warfighting. With respect to technology, he called for new efforts to streamline the development process to catch up with private sector development cycles. Finally, he made a strong case for improving the retention of a quality workforce in the entire military from the uniformed personnel to the acquisition corps. This last goal was probably the most significant new focus and reflected a growing realization during the late nineties that the DoD was losing ground on the labor front.

"The events of September 11, 2001 raised dramatically the urgency of solving acquisition problems."

The Goldwater Nichols Act of 1986 coupled with the Secretary of Defense Dick Cheney's Defense Management Review of 1989, formed the groundwork for a professional acquisition workforce by "establishing in each military department a dedicated corps of military officers who will be acquisition specialists" (DoD DMR, 1989). This sweeping change was not accepted across the board as a good thing for the services, but according to the General Accounting Office (GAO)

investigations conducted after 1986, the Army was clearly leading the way to implementing the provisions of Goldwater-Nichols and Defense Management Review (DMR). Major General Dick Stephenson, then the senior Army aviation acquisition professional on active duty, stated that the full implementation of the Army Acquisition Corps would result in the "formation of another Army Veterinary Corps"... where the officers of the corps would lose all credibility with the warfighting side of the Army.

On the civilian side of the labor force, as a result of successive hiring freezes and senior grade restrictions, the average age of the workforce is rapidly approaching 50 years of age with few experienced acquisition civilians ready to fill the gap of the retiring workforce. Over the last ten years, the acquisition workforce grew farther and farther apart from the main stream Army. This rift in cultures between the warfighters and acquisition officers forced the most senior officers in the Army to question the net value of acquisition general officers to the business case of the Army.

"Over the last ten years, the acquisition work force grew farther and farther apart from the main stream Army."

The Comanche program, since its inception as the Light Helicopter Experimental (LHX), was managed by a General Officer; but in 2001, with the Comanche budget exceeding $1 billion annually, the Army downgraded the Program Manager (PM) position to a Colonel. Ironically, this degradation of rank compared to authority and responsibility is in contrast to the warfighting changes to the Army in the Objective Force, in which more senior ranking personnel command smaller units. Between 2001 and 2002, the Comanche Program Management Office (PMO) lost over 120 years of civilian experience as all of the most senior acquisition personnel in the PMO attained retirement age and departed government service over a nine-month period. In order to fill these vacancies, the PM was forced to seek candidates outside of civil service in order to find qualified replacements because no qualified government candidates applied. This trend seems to support the shift in vision by Rumsfeld toward development of the acquisition corps itself.

Cancellation of 5000 Series — October 30, 2002 USD Paul Wolfowitz

On August 29, 2002, a draft memo was circulated from the Secretary of Defense titled: *Operation of the Defense Acquisition System* issuing interim guidance for the acquisition community in light of the pending cancellation of the 5000 series of documents. The memo to cancel the 5000.1 D (directive), the 5000.2 I (instruction), and the 5000.2 R (regulation) documents was later issued by the DUSD (AT&L) Paul Wolfowitz on October 30, 2002. Canceling all of these sent a strong signal throughout the acquisition corps that incremental and piecemeal programmatic approaches were not acceptable solutions to the transformation problem.

The cancellation memo laid out a clear message by stating that the 5000 documents are "overly prescriptive and do not constitute an acquisition policy environment that fosters efficiency, creativity, and innovation." It went on to state further that the interim guidance issued separately is

Table 1. The Seven Key Documents Reviewed

Document	Title	Definition of Problem	Acquisition Impact	Focus of Effort
National Performance Review VP Al Gore Sept. 7, 1993	From Red Tape to Results: Creating a Government that Works Better and Costs Less	1. Rules made for era of stratified retailing. 2. Overly focused on fraud prevention. 3. Govt required specs on non-essential items. 4. Govt spends more for same commercially available parts. 5. Private sector compliance burden of regulations. 6. Proliferation of unneeded regulations.	1. Unnecessary rules and procedures. 2. Heavy burden of bureaucracy and procedures. 3. Adds time to process and paperwork. 4. Wastes money on specifications not important. 5. Compliance cost estimated at $430 Billion/year. 6. Lack of change motivation (system inertia).	1. Simplify the Procurement Process. 2. Rely More on Commercial Marketplace. 3. Eliminate the Regulatory Burden.
Perry Memo Plan Delivered to House Armed Services Committee and Governmental Affairs Committee Feb. 9, 1994	Acquisition Reform: A Mandate for Change Maintaining Technological Superiority & a Strong National Industrial Base	1. Industrial Age Big Contracts Mentality. 2. Low Risk and High Control of Process. 3. DoD small % of commercial purchases. 4. Cycle Time 10+ years vs industry 4 yrs. 5. Compliance burden of regulations. 6. Dispersed functional responsibility.	1. Consolidation of industry and erosion of base. 2. Obsession with system, process and programs. 3. Lack of interest from commercial sector (no wins). 4. Deployment of obsolete technology. 5. Unnecessary cost, wastes money for field. 6. Lack of change motivation (system inertia).	1. Cultural Change. 2. Technology Flow. 3. Bureaucracy.
DUSD (AR) Acquisition Reform – Colleen Preston - 1995 Reengineer the Acquisition System	Statement by DUSD (AR) Mrs. Colleen Preston on Acquisition Reform before Committee on National Security US House of Rep.	1. Warfighter is Customer but is not present. 2. Change is not embraced within the DoD. 3. Do not emulate commercial best practices. 4. Too many defense only suppliers. 5. Not oriented on performance outcomes.	1. Long Acq Lead times 2. No one willing to take any risk. 3. High costs and inefficient. 4. Some suppliers are not willing to sell to DoD. 5. Excessive protests filed as way of getting business.	1. Improve Responsiveness. 2. Reduce Costs. 3. Facilitate Merger of Defense and Commercial Industrial Bases.
Defense Reform Initiative Report (DRI) 1997 William Cohen Secretary of Defense	Leading Change in a New Era (The DRI Office was officially launched in May 1998)	1. Lack of interest from commercial sector. 2. Consolidation of industry; lack of base. 3. Revolution in Military Affairs needs support to work.	1. Potential deployment of obsolete technology. 2. Obsession with system, lack of motivation to change. 3. Unnecessary costs wastes money for field.	1. Reengineer. 2. Consolidate. 3. Compete. 4. Eliminate.

Table 1. The Seven Key Documents Reviewed (continued)

Document	Title	Definition of Problem	Acquisition Impact	Focus of Effort
The Road Ahead June 2, 2000, USD(AT&L) J.S. Gansler, Launch of the Acquisition Initiatives Office in the OSD	Accelerating the Transformation of Department of Defense Acquisition and Logistics Processes and Practices	1. Supporting the RMA to meet threats of asymmetric warfare. 2. Need for high interoperability among U.S. Forces. 3. Development dollars squeezed by flat budget lines and rising support costs.	1. Acquisition support system not in tune with RMA (needs RBA in department). 2. Too many barriers to change. 3. Not keeping pace with technology development (falling R&D investments and cycle times).	1. Reduce acquisition cycle times for technology. 2. Lower total ownership costs. 3. Reduce overhead of support (A&L).
Rumsfeld's Vision of Reform Sept. 10, 2001	Bureaucracy to Battlefield	1. Waste of resources. 2. Outdated systems. 3. Redundant processes.	1. Supporting the RMA to meet threats of asymmetric warfare. 2. Need for high interoperability among U.S. Forces. 3. Development dollars squeezed by flat budget lines and rising support costs.	1. Reduce cycle time. 2. Improve workforce morale. 3. Strengthen health of industrial base. 4. Leverage commercial technology insertion.
Cancellation of the 5000 Series Wolfowitz, 2002 Rapidly deliver affordable, sustainable capability to meet warfighter needs	Draft Memo Circulated (later signed)	1. Current 5000 set is overly prescriptive (The PM shall...). 2. 5000 does not create the desired new acquisition policy environment. 3. Does not foster efficiency, creativity, and innovation.	1. Remove proscriptive nature of 5000 series to allow more PM discretion.	1. Flexible. 2. Innovative. 3. Speed in technology deployment.

to "rapidly deliver affordable, sustainable capability to the warfighter that meets the warfighter's needs." Thus the three tenets from 'The Road Ahead' of faster, cheaper, cheaper were reiterated here in the interim guidance but the driving reason for change was still a need for fundamental cultural change (fostering the favorable policy environment).

The faster/cheaper message does not carry the same kind of urgency for deep change that the Perry memo called for. Thus, it is understandable that the DRI and its successor, the OSD AI office, operated primarily from a mandate of programmatic fixes to demonstrate cost savings/avoidance. A year after the Rumsfeld September 10, 2001 call for an overhaul to the Pentagon bureaucracy, the efforts (5000 updates, program management tools implementation, etc.) were still not structured in a way that could add up to the fundamental type of change demanded by Perry in 1994, Gansler in

1999, or Rumsfeld in 2001. Table 1 summarizes the key points from each of the eight documents reviewed and forms the baseline of reference for this paper.

Next we examine the eight documents in light of the key drivers of acquisition reform. Then we return to look at the tensions remaining in the change vision and what can be learned from this decade of change effort.

The Need for Change

Changing Needs of Warfighters

Many recurring issues have driven efforts at change in the DoD over the last decade. Three key drivers continue to surface throughout the statements and documents relevant to transformation. First are the changing demands of the warfighters. The battlefield has become a technological platform. To respond to growing unconventional threats and asymmetrical warfare, military requirements have been shifting over the last decades.

For example, the Comanche program has evolved over the years to meet a new set of requirements and warfighter needs. The Comanche (RAH-66) is now more of a systems integrator to the overall force than a modern attack helicopter. By morphing its role it has remained relevant to the new needs of the force. At the same time, the program has languished for decades competing for funds and attention to actually bring the technology to the battlefield. It has faced serious technological obsolescence issues due to long development cycles and less than desirable program structuring (Birmingham, 2002).

The vision of transformation as driven by the changing needs of warfighters (customers) is outlined in Table 2. The term *warfighter* does not appear in the NPR, but it was quickly adopted within the DoD to mean the ultimate *customer* of the acquisition system. Since the needs of the customer were changing, the support structure of the acquisition community must change to meet those evolving customer needs. The warfighter as customer seemed to lose some focus near the end of the 1990s not appearing in documents relating to the DRI and OSD AI. As the decade progresses, more and more attention was given to the technology flows, the shifting defense industrial base, and slipping market power of the DoD in breaking technological fields perhaps assuming the warfighter needs were being addressed.

"The term *warfighter* does not appear in the NPR, but it was quickly adopted within the DoD to mean the ultimate *customer* of the acquisition system."

Shifts in Military-Industry Technology Flows

The second driver closely linked to the first is the commercial rate of technological development. Military acquisition cycles are as much as 2.5 times longer than commercial cycles. Technological advances can quickly appear on the threat horizon creating the very real possibility that U.S. Military personnel could be technologically inferior to a foe in the field solely due to the slowness of the acquisition support process. Secretary Rumsfeld directly attacked

Table 2. Tracing the Changing Needs of the Customer (Warfighter)

Reference Document	Characterization of Acquisition Problem	Reference to Warfighters Needs
National Performance Review Gore, 1993	"Industrial-Era Bureaucracies in an Information Age"	"tough global competition." "demanding customers."
Perry Memo, 1994	Current acquisition system does not support a strong national defense industrial base.	"the threats are changing and unpredictable."
Colleen Preston, 1995 (p. 2)	"new national security challenges require a more flexible, agile and timely acquisition process." Lead times are too long to field equipment/technology.	"meet warfighter needs"... we must be 'capable of meeting unpredictable needs.' Warfighter is customer but is not present in the process.
Defense Reform Initiative, 1997	Reallocating resources 'from overhead and support activities to our fighting forces.	Enhancing efforts to defend against asymmetric threats. Joint Vision 2010; information use and denial in battle.
The Road Ahead, 1999	Revolution in Military Affairs must be supported by Revolution in Business Affairs.	Unpredictable threats, rogue nations, use of weapons of mass destruction (WMD).
Rumsfeld's Vision, 2001	Pentagon Bureaucracy. Institutional Inertia. Dollar wasted is one denied to the warfighter (efficiency) Overcapacity of bases.	Must change to meet new world challenges of multiple threats of unpredictable source and nature. Excellence in functions related to warfighting.
Wolfowitz's Memo Cancelling the 5000 Series	Overly prescriptive; Does not foster efficiency, creativity and innovation.	"to rapidly deliver affordable, sustainable capability to the warfighter that meets the warfighter's needs."

this bureaucratic threat on September 10, 2001 when he outlined his vision for the new way of doing business in the Pentagon. One outcome of changes in technology flows is that the military has found itself struggling to keep pace with technological developments due to either disinterest on the part of commercial developers or cumbersome DoD acquisition systems.

The dynamics behind this shift in market power (the DoD used to be the major buyer of technology) goes back to the aftermath of World War II. As wartime production ended, the Cold War helped sustain predictable and steady

Table 3.
Tracing the Changing Nature of Technology and Industry Dynamics

Reference Document	Characterization of Acquisition Problem	Reference to Industry and Technology Dynamics
National Performance Review Gore, 1993	"Industrial-Era Bureaucracies in an Information Age" Faulty economic assumptions of scale efficiency and faulty managerial assumptions of audit, compliance and control.	"tough global competition" "demanding customers"
Perry Memo, 1994	"shrinking defense industrial base;" "commercial technology advancements are outpacing DoD sponsored efforts."	1965 Military consumed 75% of semiconductor production; 1995 consumed around 1%. Commercial design cycle is 3-4 yrs; DoD 8-10 yrs.
Acquisition Reform, DUSD(AR) Colleen Preston, 1995	Too many defense-only suppliers. "facilitate the merger of the defense and industrial bases.	Some suppliers unwilling to sell to DoD (hassle factor prohibitive). Not emulating best commercial practices.
Defense Reform Initiative, 1997	Consolidation of industry and erosion of core capabilities. Lack of interest from commercial sector.	RMA will outrun ability of Acq System to support it. Deployment of outdated technology to the field.
The Road Ahead, 1999	Logistics response too slow; Acq cycle too long.	Integrate a civil-military industrial base.
Rumsfeld's Challenge, 2001	Bureaucratic inertia; Excess infrastructure. PPBS outdated.	Technology moves faster than the DoD System. Deploying outdated technology.
Cancellation of 5000 Series, Wolfowitz, 2002	Rapid movement from S&T to Deployment and FieldingIntegrated T&E Improved Cycle Time	Overly prescriptive regulations do not foster innovation and flexibility in program management to keep up with technology.

TERMS:
PPBS – Program Planning Budget System
S&T – Science and Technology
T&E – Test and Evaluation
RMA – Revolution in Military Affairs

improvements in materiel and systems to counter the static Soviet threat. As the technology boom of the nineties took off and the Cold War ended, industry rushed off to richer commercial markets and the military industrial base was threatened with an erosion of core capability. The defense industry consolidated as major program awards dwindled and the predictability of defense business declined rapidly. As has happened in other consolidating industries — railroads, steel, and telecommunications — the power of unions became concentrated limiting further the ability of defense contractors to control labor costs or move production work to more efficient locations.

In tracing the vision of acquisition reform as it relates to technology, two themes are intertwined: loss of DoD market influence on the defense industry and cycle time gap between military and commercial technology applications. The vision from Gore and Perry focused on dealing with shrinking military-industrial base by first commercializing the technology developed for the military thereby helping industry to profit from defense related work; and second, by using more commercial technology in defense programs thereby lowering the DoD acquisition costs.

The twin needs of speed and support are embedded in these efforts but seem to gain more focus toward the end of the decade. Notice in Table 3 how the health of the defense industry is an objective up through 1995. It still receives mention in 1997 and 2001 but more as a principle of change, not a focus of change itself. Thus, the vision for change with respect to technology seems to have shifted from building a new military industrial reality to more simply reducing technology deployment cycle time.

Another way to interpret this is that the focus shifted from a perceived complex root cause to a tangible demanding result. It is also possible that the vision shifted because the threat of technological inferiority became a real crisis. Thus, the industry alignment became eclipsed by the immediate need to get technology to the troops faster. The shift makes it easier for Rumsfeld to connect change (meaning rapid fielding of technology) to meeting warfighter needs. It is probably much more difficult to take on fixing the defense industry capability, which is fraught with political, labor, economic, and international concerns that make it difficult to see meaningful progress.

Table 3 outlines the key elements of the change vision as it relates to technology throughout the decade.

Defense Budget Constraints

The third key driver of change is budget and spending constraints. The initial vision declared that the government must actually spend less and, indeed, defense budgets had been declining in the late eighties and through most of the nineties. About half way through the decade the emphasis seems to shift from an absolute cost reduction to a reduction in overhead allowing more money for technology and R&D. This focus is most notable in Rumsfeld's comments on September 10, 2001 when he spells out a vision for not reducing overall cost but for reducing waste allowing for more productive use of the same funding. This part of the vision probably changed the most and even more so after September 11, 2001. As defense budgets began to expand

Table 4. Tracing the Shrinking Defense Budget as a Driver of Change

Reference Document	Characterization of Acquisition Problem.	Reference to Changing Defense Budgets.
National Performance Review Gore, 1993	"The federal government seems unable to abandon the obsolete." "Waste and inefficiency; loss of faith of taxpayer to fund it."	"government must cost less" "reducing the federal deficit"
Perry Memo, 1994	DoD pays more for same parts due to regulatory burden. Lack of access to commercial supply and surge production.	Defense spending in real terms has declined by 40% from FY 1985 to FY 1997.
Acquisition Reform DUSD(AR) Colleen Preston, 1995	More firms become defense only suppliers (dependent).	Reduce costs; Procure best value goods and services.
Defense Reform Initiative, 1997	Revolution in Business Affairs must support Revolution in Military Affairs	Resources must be freed up to invest in new R&D.
The Road Ahead, 1999	Total ownership costs too high. Support costs and overhead growing too fast.	Reduce support costs; Reduce overhead costs.
Rumsfeld's Challenge, 2001	Excess infrastructure (bases). Redundant staff and agencies. Inefficient systems/processes.	Public trust for tax dollars spent on defense; Waste drains resources needed for addressing new threats.
Cancellation of 5000 Series, Wolfowitz, 2002	Need total systems approach to acquisition management. Performance based logistics Cross service acquisition agreements	Overly prescriptive regulations do not foster efficiency of operations; cost realism or program stability.

again, the focus shifted even more to spending it on the right things and particularly getting the technology into the warfighters hands faster and more efficiently. Figure 1 shows overall defense spending during the decade of transformation.

Table 4 traces the vision of change as driven by budgetary concerns. The shift in perspective roughly correlates with the change in administrations, the end of Base Realignment and Closure (BRAC) (93 & 95) rounds and the onset of the terrorist war. One thing is clear

Information Technology Projects ACAT IA - III			
	ACAT IA	ACAT II	ACAT III
Total Life Cycle Costs	> $378,000,000	N/A	< ACAT I
Total Program Cost	> $126,000,000	N/A	< ACAT I
Total Program Costs (all appropriations) in any single year	> $32,000,000	N/A	< ACAT I

Note: All $ amounts are expressed in FY2000 constant dollars
Source: DOD Instruction 5000.2, May 12, 2003, Enclosure 2

Figure 1. Percent Real Growth in Defense Spending

— the spending patterns will not be the same as in the post–World War II and Cold War periods. Large multi-year cost-plus contracts are gone. The new environment of performance-based contracts and milestone development protects the budget from being devoured by program growth but at the same time has introduced a high level of uncertainty into the program management side of acquisition. This has in turn affected the relationship between the DoD and industry exacerbating the already weak industrial base. It is also likely that continued budgetary constraints because of the demands of homeland security will make cost efficiency and cost-effectiveness essential to all military spending plans.

Observations for Further Empirical Research

Lessons Learned from the Decade

What does the review of these documents tell us? There are several general observations and many research questions generated from a review such as this. First, visions change with vision owners and changing visions make it difficult to maintain change momentum. Changing visions also create potential for less than full realization of change consequences as change agents become overly focused on achieving some measure of change during their term in power. This emphasis on demonstrable action and results can diminish the effectiveness of even well thought out visions and plans.

Second, visions do naturally evolve with time. Not just because of changing vision owners but also because of changing environmental conditions as with the changing threats the U.S. Military must counter. But changing environments also come from within as in the changing workforce, federal labor acts, and technology driven product life cycles. In the midst of change — of the change vision itself — clear pictures of the desired end states may be even more important. Thus, it would seem important for leaders to focus on maintaining a clear and compelling vision (picture) of where we are

going in the midst of evolving change plans and programs.

Tensions in the Change Process

Faster vs. Cheaper

In examining the status and number of DoD program starts, restarts, and cancellations over the last ten years, it is obvious that the DoD track record for keeping programs on schedule and within cost has not been impressive. Both industry and DoD program manager's have suffered from a contagious trend of unmerited optimism in defining and supporting both cost and schedule program risks, especially across the most complex programs such as V-22, F-22, and Comanche. The initial program baselines were built around making the programs fit inside a constricting cost and schedule box vs. designing program plans within flexible boxes to accommodate the many unknowns associated with complex integration initiatives. The current DoD acquisition administration's recognition of the problem has been outlined with recent Cost Analysis Integration Group (CAIG) guidance to put realism into the program plans. Evidence of this realism can be seen in the high number of program Nunn-McCurdy breaches occurring over the past few years.

In Army aviation alone, Comanche, Chinook, and Blackhawk have all exceeded program breach thresholds from baselines between 2001 and 2003, baselines that were inadequately established for reasons of keeping the programs alive and on schedule. Further examination of the Comanche history indicates a pervasive *give it ALL to me faster* philosophy despite changes to requirements and the reality that not all capabilities can be delivered within the same program risk profile. Despite efforts from OSD AT&L leadership to make the TRADOC community accountable for the approved set of requirements in addition to requirements creep, few in TRADOC recognize or understand programmatic impacts to Cost As an Independent Variable (CAIV) analyses.

General Abrams, in April 2001, in a briefing to the Army Chief of Staff in which he was justifying a new set of Objective Force requirements for the program plan, stated that the "Comanche weight growth experienced over the last 13 years is the result of the Army Acquisition Corps' inability to keep discipline within the requirements process." Ironically, this was the same briefing in which the Program Manager stated to the Chief of Staff, Army (CSA) that based on the current contractor performance and expanded set of requirements, "all program goals and objective could not be met."

"The prospect to do smart things cheaper and faster is a dual edge sword."

The complexity of the interrelationship between TRADOC and Acquisition is further strained as DoD programs continuously undergo a systemic decrement of program funding after contracts are signed and executed. The prospect to do smart things cheaper and faster is a dual edge sword. Development Program Managers on both the industry and DoD side must constantly search for ways to do business cheaper and faster...just to keep up with the annual drain of funding.

For fielded system Program Managers, the problem of doing business cheaper and faster is often confused

between efforts, which are cost saving vs. cost avoiding. Cost saving efforts, almost always will be accompanied with a reduction in program budgets far ahead of the realization of the cost savings. Cost avoidance is a more agreeable term for the near term but pays the same penalty in the out-years.

Standardized vs. Latest Technology

The concept of evolutionary acquisition is not new. For the past ten plus years, DoD program managers have modified their fielded systems with technology insertions, usually benefiting from commercial innovations. Over the last ten years, the shift from a DoD centric technology base — where much of the warfighting technology was developed for and within the DoD military-industrial base to — commercial centric technology development. DoD programs have become hostages to the velocity and pace of commercial standards and demands. To survive, program managers had to shift their development and technology insertion strategies from leader to follower — often becoming the tail end of scalable products. Although this strategy has helped to slow down the pace of obsolescence, little has been done to address the Program, Planning, Budgeting and Execution System (PPBES) and process to pay for these efforts.

"Planning for technology upgrades and phased recapitalization lacks support across the DoD budget leadership."

The Apache Forward Looking Infrared (FLIR) technology lagged behind the commercial standard, not because of availability of technology but because funding was not planned well in advance of the technological maturity and test complete dates. Comanche has changed its mission processing technology three times since 1991, not because additional processing capability was required but because INTEL chose not to manufacture a Comanche-only P133/233 and transfer controller. To plan for a smooth transition to production plan, the Comanche program manager was challenged to hold a development baseline configuration through the first few lots of production in order to keep development on schedule and keep costs down. Without a special, congressionally approved reprogramming action, the program would have been forced to change processing architectures in mid-development — further delaying the fielding of the system.

Configuration management of DoD systems, particularly non-commercial off-the-shelf (COTS) systems present another unique challenge for DoD program managers. Since DoD systems are not fielded like Ford automobiles, multiple configurations of the same system is *a given*. Comanche will field 650[2] aircraft starting in 2008 and complete fielding in 2020. Using the last ten years as a model, it is likely that there will be at least four different Comanche configurations in our Army when the last lot of aircraft is delivered. Planning for technology upgrades and phased recapitalization lacks support across the DoD budget leadership. DoD will not plan for funding against notional requirement changes and obsolescence when current operations and fiscal shortfalls to current systems exist. The consequence has been the need for greater Operation and Support (O&S) dollars to support multiple systems, and this trend does not seem likely to change.

Test management and requirements has gained considerable momentum over the last ten years and has almost ignored the rapid growth of models and simulations. Live fire testing requirements remain a congressional mandate and DoD 5000 policy has given the test community a tilted balance of power in the material acquisition process. Although most program managers support a robust test and evaluation plan for their systems, escalating costs of redundant testing has forced program managers to stretch program schedules to accommodate required operational test plans and their associated funding requirements.

Evolutionary acquisition procedures have not gained widespread approval from the test community, as most program plans still require a major, expensive graduation exercise called Initial Operational Test and Evaluation (IOT&E). Since the Low Rate Initial Production (LRIP) decision occurs well ahead of the IOT&E, the Limited User Test (LUT) baseline for the LRIP Defense Acquisition Board (DAB) has gained importance to become the program plan center of gravity. Testers have translated this *operational assessment* into as much of an IOT&E as possible. Both Army testers and Director of Operational Test and Evaluation (DOTE) required that the Comanche program conduct a side-by-side test with the Kiowa Warrior prior to the LRIP DAB — *to determine its overall suitability*. Both the Army Vice Chief of Staff and Army Acquisitions Executive questioned this philosophy as being "outdated and ridiculous to use an aircraft that is being phased out and has everything known about it on paper."

Finally, it is important to ask if there is any difference between Rumsfeld's challenge to the Pentagon in 2001 and Perry's Mandate in 1994? Both call for radical change to the normal way business is done at the Pentagon. Does Rumsfeld's call imply that Perry's vision has not been implemented or is it the necessary restatement of the urgency required to maintain change momentum? How much urgency is required to keep a vision alive? What causes a clear vision to change course and lose sight of the original goal or adopt a new focus? Perhaps further empirical research can document the effects of these shifts in vision within the DoD reform experience.

Conclusions

Critics of reform often say it is all tied up in politics with little hope of change. Deborah Frank outlined this argument succinctly in an article printed in the *Acquisition Review Quarterly* journal (Frank, 1997). Her argument, based on systems theory, suggested that with no change in the political process, there is little hope for real change in the acquisition process. Acquisition funds are too susceptible to political influence for other than military ends. While this is always true in the American model that gives ultimate control of the military to elected officials, it does not preclude the ability of a bureaucracy to change itself over time driven by clear change visions.

We think there are several lessons to be learned from this paper and hopefully much more detailed research to be done into the effects of the change efforts already under way. This review of

transformation efforts shows the length of time and level of persistence needed to effect real change in a bureaucracy as large as the DoD. Continued strong leadership and clarity of purpose will hopefully bring about deep and substantial progress in the in the years ahead.

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ENDNOTES

1. The document was actually signed by DUSD (AT&L) J. S. Gansler on June 2, 2000 but had been widely circulated within the acquisition community since the middle of 1999.
2. The Army requirement was for 819, but the Defense Acquisition Board only approved 650.

References

Birmingham, R. P. (2002, March 31). RAH-66 Comanche: Adjusting for the warfighter. *Army Aviation Magazine 51*(3), 10, 30.

Defense Management Review (DMR). (1989, July). Defense management: Report to the President. Secretary of Defense Cheney, Department of Defense. Retrieved March 17, 2004 from http://www.defenselink.mil/nii/bpr/bprcd/289a.htm

Frank, D. (1997). A theoretical consideration on acquisition reform. *Acquisition Review Quarterly, 4*(3), 279–293.

Gansler J. S. (2000). The road ahead: Accelerating the transformation of Department of Defense acquisition and logistics processes and practices. Department of Defense. Retrieved from http://www.acq.osd.mil/ar/doc/mand24.pdf

Gore, A., & The National Performance Review (1993). *From red tape to results: Creating a government that works better and costs less.* Report. Fredonia Books.

McNaugher, T. L. (1990). *Defense management reform: For better or for worse?* Washington, DC: The Brookings Institution.

Perry, W. J. (1994). *Acquisition reform: A mandate for change.* Plan provided by Secretary of Defense Perry to the House Armed Services Committee and the Governmental Affairs Committee, February 9, 1994. Washington, DC: Department of Defense. Retrieved from http://www.dod.mil/execsec/adr95/acq.html

Preston, C. (1994). Acquisition reform: Making it a reality. *Acquisition Review Quarterly, 1*(1), 6–11.

Preston, C. (1995b). The Administration agenda for acquisition reform. Defense Issues. (DUSD[AR]). Colleen A. Preston on acquisition reform. Retrieved March 2, 2004 from http://www.defenselink.mil/speeches/1995/t19950406-preston.html

Preston, C. (1995b). The Administration Agenda for Acquisition Reform. *Defense Issues, 10*(39). Retrieved March 2, 2004 from http://www.defenselink.mil/speeches/1995/t19950406-preston.html

Rumsfeld, D. (2001, September 10). *DoD acquisition and logistics excellence week kickoff — Bureaucracy to battlefield.* Remarks as delivered by Secretary of Defense Donald H. Rumsfeld, The Pentagon. Published on DefenseLink at: www.defenselink.mil. speeches/2001

Wolfowitz, P. (2002, August 29). *The defense acquisition system.* Memo. Retrieved from DAU Website.

Additional Suggested Reading

Acquisition Reform Implementation: An Industry Survey. (1997). DoD Services Acquisition Executives prepared by Coopers and Lybrand.

Beck, C. L., Brokaw, N. L., & B. A. Kelmar. (1997). *DSMC—A model for leading change: Making acquisition reform work.* Fort Belvoir, VA: Defense Systems Management College Press.

Birkler, J., Smith, G., Kent, G. A., & Johnson, R. V. (2000). *An acquisition strategy, process, and organization for innovative systems.* Research Report. The Rand Corporation.

Defense Reform 2000. (2000). *On the road to excellence DRI checkpoint.* Retrieved from http://www.defenselink.mil/dodreform/dricdrom/intro.htm

Defense Reform Initiative. (2000). *Overview: Stat sheet of DRI successes.* Office of the Secretary of Defense. Retrieved from http://www.defenselink.mil/dodreform/dricdrom/overview.html

Federal Acquisition Streamlining Act 1994. (1994). Retrieved from http://thomas.loc.gov/cgi-bin/t2GPO

Gansler, J. S., & Lipitz, R. C. (2002). *A vision of the government as a world-class buyer: Major procurement issues for the coming decade.* The PricewaterhouseCoopers Endowment for the Business of Government.

Kuhn, R. L. (Ed.). (1993). Generating creativity and innovation in large bureaucracies. Westport, CT: Quorum Books.

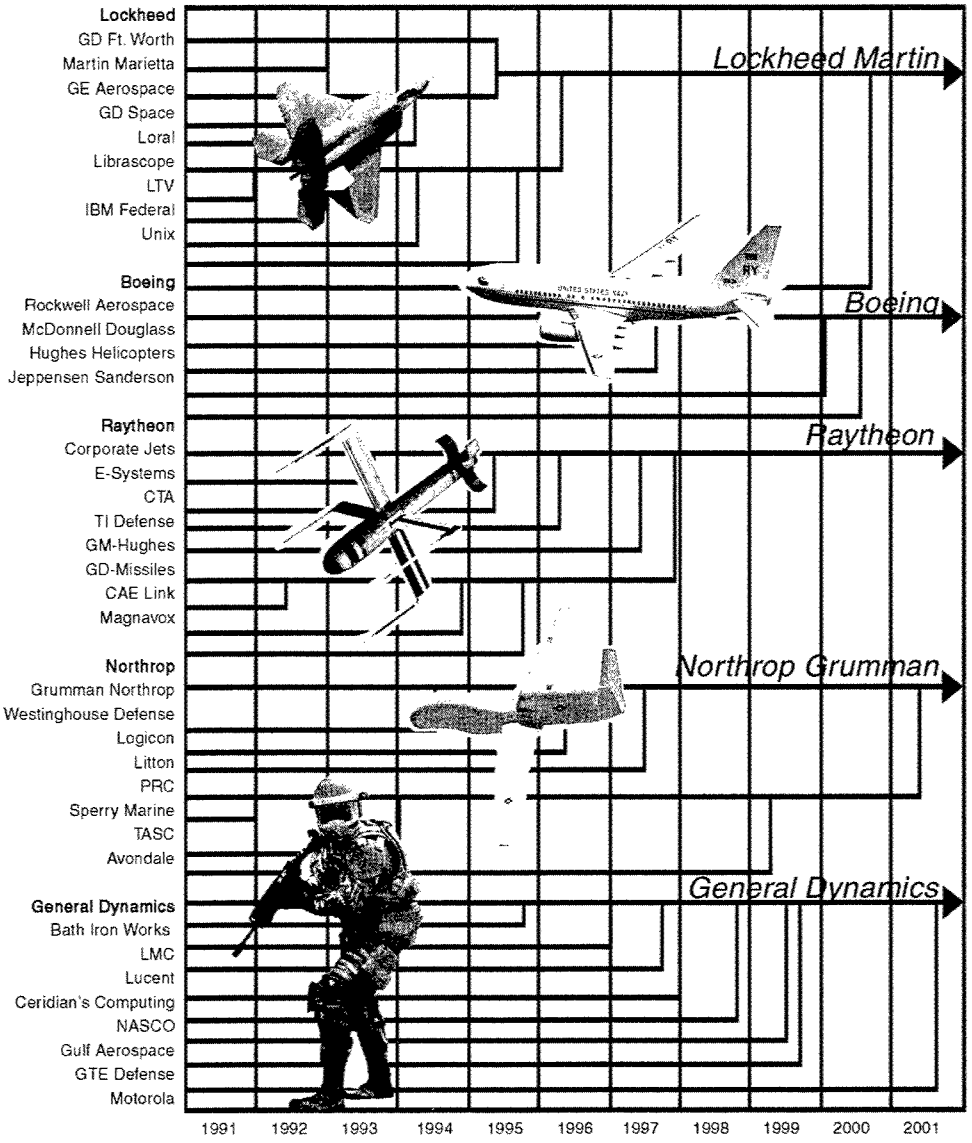
OSD AI. (2002). DoD's acquisition initiatives office goals and objectives. Retrieved from www.acq.osd.mil/ar

Schmidt, C. P. (2000). *Changing bureaucratic behavior: Acquisition reform in the U.S. Army.* Research Report. The Rand Corporation.

Secretary of defense report to congress: Actions to accelerate the movement to the new workforce vision. Retrieved from http://www.acq.osd.mil/ar/912crpt.html

The DoD regulatory cost premium: A quantitative assessment. (1994). Prepared for Secretary of Defense William J. Cohen by Coopers & Lybrand. Retrieved from http://www.acq.osd.mil/ar/doc/dod_reg.pdf

Industry Consolidation



TUTORIAL

AN INITIAL LOOK AT TECHNOLOGY AND INSTITUTIONS ON DEFENSE INDUSTRY CONSOLIDATION

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Conventional wisdom holds that defense industry consolidation resulted from decreased defense spending. However, we maintain that understanding dynamic changes in key defense institutions helps provide a more complete explanation for observed consolidation. Specifically, we examine the interaction of evolving technology and changing institutions. Institutions reviewed include procurement policies, the weapons requirements process, and procurement organizations. We take an initial look at the industry, and highlight how these changes influenced transaction costs in the defense industry, more fully explain the forces driving consolidation, and provide greater insight to policy makers seeking to improve the performance of the defense industry. Further research is needed to build a robust institutional framework of the defense industry and the related government agencies to allow better policy prescriptions.

Still much of the public discussion of weapons acquisition problems proceeds as if the terms "competition," "price," "buying," and "seller" had the meanings they do in a market system.
(Peck & Scherer, 1962)

Over the past 20 years, 75 plus United States defense specialized firms/divisions merged into five major defense firms, or prime contractors (Commission on the Future of the Aerospace Industry, 2002). Almost universally the consolidation of the past 20 years has been explained as a result of decreased defense spending or capacity underutilization (e.g., Augustine, 1997; Deutch, 2001) and has been accompanied by concerns over the level of competition between remaining prime contractors (Ricks, 1996). Often the defense industry is compared with a competitive market of common commercial products and assumed to be inefficient. However, competitive markets of common commercial

products display multiple competitors and customers where prices can be predicted from given levels of supply and demand. Meanwhile, a defense market with differentiated weapon systems as products displays important differences from a classic competitive market (Peck & Scherer, 1962; Sapolsky & Gholz, 1998), and it should be recognized that assumptions about the applicability of competitive marketplaces can result in dubious policy recommendations (King & Driessnack, 2003; Langlois & Robertson, 1995).

Traditional explanations for the consolidation of the defense industry based on decreased defense spending are not consistent with a long-term view of the industry. Although recent defense industry consolidation is unprecedented, the U.S. defense budget has followed a cyclical pattern with both decreases and increases in spending since 1952 (see Figure 1). This suggests that the most recent defense industry consolidation has been driven by factors beyond decreased defense spending. Markusen's (1998) prediction that surviving defense firms would become smaller and focus more on commercial markets has not come to pass. For example, while Boeing offers both commercial and defense products, it grew larger through its acquisition of McDonnell Douglas, which increased its reliance on defense. Additionally, although mergers have consolidated the number of firms and decreased the number of personnel employed by defense firms, Department of Defense (DoD) Industrial Policy reports consistently show industry capacity has not undergone equivalent reductions.

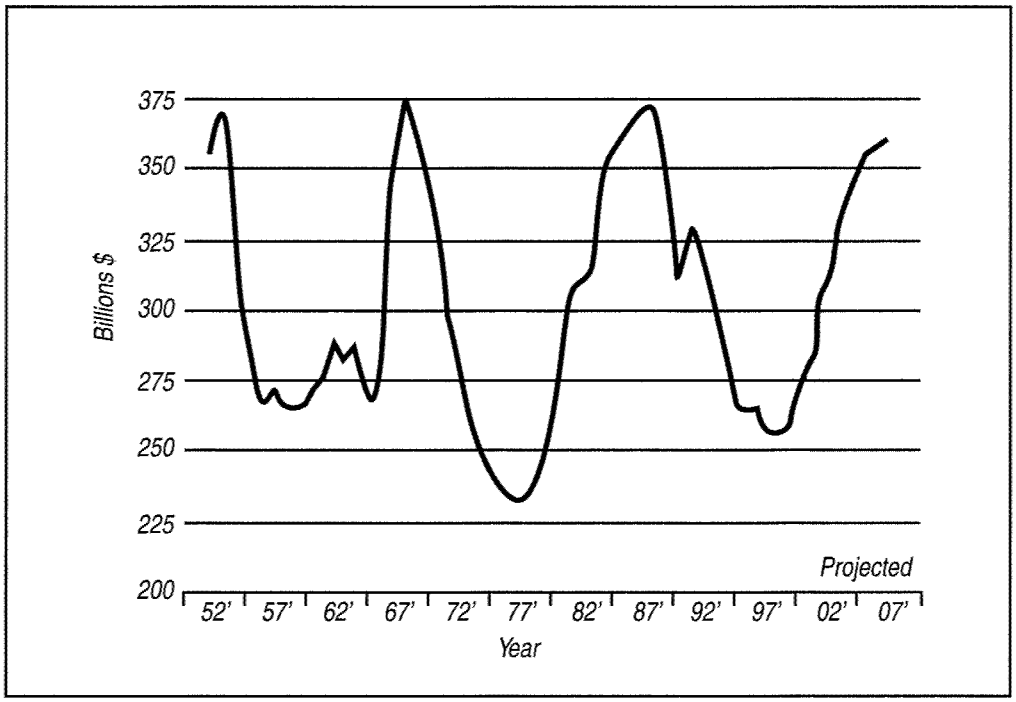


Figure 1. Defense Spending 1952-1997 in FY1996 Dollars

Peck and Scherer (1962) cautioned against applying traditional assumptions of a competitive price-driven market to the defense industry as their applicability is tenuous, at best. The defense market is unique and displays an increased role of government where it acts as both a buyer of goods and regulator of the market. Government actions predominate the defense market as it sets the rules (e.g., regulates contract types) and alone is responsible for uncertainty of demand as the sole buyer of defense goods.[1] Government represents an active institution in the defense industry, and institutions contribute to market structure by defining transaction costs (Hoskisson, 2000). The neo-classical economic view, which is often the basis of current industrial policies, minimizes the role of transaction costs and the impact of institutions on firms.

Our contribution involves applying an evolving framework called New Institutional Economics (Greenwood & Hinings, 1996; North, 1999; Williamson, 1985) to the defense industry. The result is an initial assessment of the impact of institutions in changing transaction costs, and the potential relationship these changes played in the recently observed defense industry consolidation. Existing research has recognized that transaction costs play a role in defense markets. For example, Rogerson (1994) recognized the key role of government in shaping the defense procurement process and unique characteristics that impact weapons procurement incentives. He goes on to lament that economics has largely been absent from shaping defense industry institutions and its regulatory environment because of the unique nature of defense procurement. Our goal is to facilitate a better understanding of the defense industry and its efficiency by providing a framework that allows more informed policy recommendations through a better explanation of the role of institutions in the defense industry.

Defense Industry Consolidation

Our analysis begins with a summary of the defense industry. We define defense firms similar to Chu and Waxman (1998) as firms that have established capabilities and competencies in dealing with the DoD. An important implication of this definition is that defense firms have evolved to become *specialized* in the sense that they focus on the transactions with a monopsony customer—the agencies and organizations in the DoD and not in any particular product or technology. Our initial look focuses on the top of the defense industry hierarchy, the 5 firms, Lockheed Martin, Boeing, Raytheon, Northrop Grumman, and General Dynamics, which have consolidated to increase both their share of the defense business and percentage of their business dependent on defense work.

"Defense firms sell unique products in a monopsony where the only buyer is the U.S. government."

These defense firms are public firms, but many of the similarities to commercial firms operating in the U.S. market end there. Defense firms sell unique products in a monopsony where the only buyer is the U.S. government. Contract competitions typically involve situations where 'winner takes all,' and R&D costs for

their high-technology products are largely subsidized (McNaughter, 1989; Peck & Scherer, 1962). Viewing defense firms as operating in a traditional commercial market would require that the specialized knowledge for doing business with the government could be easily obtained (Chu & Waxman, 1998). Further understanding the defense industry consolidation requires understanding a market defined by the transactions with U.S. government procurement offices utilizing highly stylized rules for contracting. We employ New Institutional Economics (NIE) to examine the role technology and institutions played in defense industry consolidation.

"There are multiple unique technologies required for different categories of weapon systems."

New Institutional Economics

The basic unit of analysis or core of the NIE framework is transaction costs and how they are determined by the interaction of changing institutions, environment, and enforcement arrangements of formal and informal market rules. When examining transaction costs, the question that needs to be resolved is on what principal dimension does a transaction differ (Williamson, 1996). Additionally, Williamson indicates that similar effort is needed to understand differences in governance structures that bring order to transactions.

Our analysis begins by examining how defense industry transactions changed as a result of the advancement in technology and the need for integrated weapons, evolving government institutions, and impact of *winner take al* contracts. Again, our goal is to see how changing institutions and transaction costs can also help explain defense industry consolidation. We do not claim that these forces are the only ones acting on defense firms. Instead, we highlight that they represent contributing forces that have not been previously examined, in comparison to decreased procurement funding. Our findings suggest that changing institutions and transaction costs provides a more complete story of the forces driving defense industry consolidation.

Evolving Technology

Technological change can have extensive impacts on the competitive dynamics of industries (Anderson & Tushman, 1990). There are multiple unique technologies required for different categories of weapon systems. We focus on providing examples from fighter aircraft where significant advances in core and supporting technologies can be observed to demonstrate that maturing technology has contributed to defense industry consolidation. As technology matures, a dominant design is established, and there is pressure for firms to consolidate, as fewer product offerings exist in a market (King, Covin & Hegarty, 2003).

In the case of fighter aircraft technology, following World War II, technology evolved from reciprocating engines to jet engines driving changes to basic aircraft design. Uncertainty about potential performance and product design drove a large number of unique aircraft designs from multiple defense firms. For example, a

total of nine prime contractors designed and flew 40 different fighter aircraft designs during the 1940s and 1950s (Lorell & Levaux, 1998). However, as jet fighter technology matured the number of aircraft designs fell with less than a dozen U.S. fighter aircraft developed since 1960. Maturing technology contributes to pressures on major defense firms to consolidate as fewer aircraft designs required fewer prime contractors that are capable of integrating and manufacturing fighter aircraft. A related observation that supports this statement is that there have been no new entrants into U.S. manned aircraft production since 1945 (Birkler, Bower, Drezner, Lee, Lorell, Smith, Trimble, &Younossi, 2003). Additionally, the aircraft types that are produced are maintained longer and upgraded more often. Upgrade contracts are typically awarded to the original prime contractor, requiring defense firms to retain a workforce able to manage multiple technology insertion programs.

The award of the F-22 Raptor and F-35 Joint Strike Fighter contracts to Lockheed Martin has resulted in a situation where no other new manned fighter aircraft program is in design or planned to be in design for at least the next 10 years. This reduction in the number of aircraft designs may be far more influential on industry consolidation than decreased defense spending. For example, the Joint Strike Fighter is the largest DoD program to date in terms of its anticipated budget value. The consolidation of aircraft type is also consistent with bomber and cargo aircraft. We maintain this consolidation of weapon systems influenced industry consolidation more than the cycles in defense spending. However, institutional factors also contributed to defense industry consolidation.

Changing Institutions

In looking at the consolidation in the defense industry it is important to consider the changing institutions. Institutions are the formal and informal rules along with their enforcement arrangements that influence the nature of the transactions and their costs (Furubotn & Richter, 1998). Combined with evolving technology, changing institutions have influenced market forces within the defense industry. We summarize the forces that have influenced defense firms with the goal of providing insight on the drivers of defense industry consolidation beyond decreased defense spending. Specifically, the evolution of government procurement practices has likely impacted consolidation within the defense industry. We examine the government procurement practices in three areas—defense procurement policy, requirements generation, and the organization of government procurement agencies—that shape the interaction of exchanges between the government and defense contractors.

"Maturing technology contributes to pressures on major defense firms to consolidate as fewer aircraft designs required fewer prime contractors that are capable of integrating and manufacturing fighter aircraft."

Procurement Policy

Since WWII, a set of diverse organizations in each service evolved from their

various histories to manage weapons system procurement. The government did not buy as a monopsony, instead numerous organizations for each service acted as independent actors on the market for particular service weapons. The policies of these organizations have evolved to become unified with the development of common policies and regulations. Government procurement policies and regulations are outlined in the DoD 5000 series regulations and contractual management procedures (the interface with commercial industry) in the form of the Federal Acquisition Regulation (FAR). These procurement practices define the interaction between the government and firms in the defense industry.

"In general, 20 years ago contractors *specialized* not only on a particular weapon system, but also on the unique procurement organization within each armed service."

The FAR has evolved as an all-encompassing regulation governing federal procurement in the past 20 years—a period that aligns with the defense industry's consolidation. The origin of the present day FAR was the Armed Services Procurement Act of 1947 (Nagle, 1999). Following that act the number and size of regulations governing procurement steadily grew. By 1979, there were 877 different sets of procurement regulations including directives, bulletins, and instructions, comprising 64,600 pages of regulations. Since then, the specific policies for each armed service and the various other non-DoD government agencies have been consolidating into a single federal regulation. Progress has been made to establish the FAR as the single federal procurement policy (Nagle, 1999).

In general, 20 years ago contractors *specialized* not only on a particular weapon system, but also on the unique procurement organization within each armed service. For example, as recently as the 1980s, each Service had separate contract monitoring processes that drove firms to specialize in dealing with individual armed services. If a firm did business with multiple branches of the military, it was not unusual for each service to have its own contract monitoring personnel assigned to a firm's plant full time.

This has changed over the past 20 years with a series of unifying events. One example is the single-process initiative (SPI) that began, in 1994, and in a matter of two-years time relieved defense firms from multiple processes driven by numerous government procurement offices. The oversight was placed under a single defense agency, Defense Contract Management Agency (DCMA), eliminating almost all of the unique service-oriented contract monitoring offices.

The creation of a single office further contributed to the standardization of government processes. It should be noted that the single process initiative did not eliminate the unique requirements of the government, but reduced the ability of the different DoD agencies and services to require unique processes. The contractor could have a single set of processes for a given facility or across multiple facilities. As government procurement became more standardized, defense firms were less constrained to specializing for each armed service—widening their

opportunities to take advantage of their specialization. This may have contributed to defense industry consolidation in that niche firms may have decided to exit the industry as they realized their niche would be encroached upon as uniform government procurement practices increased competition and reduced transaction costs required to deal with multiple armed service weapons procurement organizations.

The same consolidation and standardization that happened on the FAR also occurred with the DoD 5000 series; the policy focused on government procurement processes and thus influenced the structure of the procurement organizations. The 5000 series was first issued in July 1971, as an initiative of then Deputy Secretary of Defense David Packard (Przemieniecki, 1993) with the primary theme of centralized policy and decentralized execution (Ferrara, 1996). The initial focus was on the procurement of major weapon systems, allowing the services to continue to acquire non-major systems under their own policies. However, in 1987, the 5000 series was extended to all procurement programs, and consolidated over 60 different directives, instructions and memoranda. The 5000 series has continued to reduce the number of unique armed services processes. This reduction along with the evolving technology and move toward joint programs (more than one armed service involved) has moved the various armed services toward a single monopsony (single customer) versus a collection of monopsony buying related but not the same products. An example is the past purchase of fighter aircraft by the Navy, like F/A-18s, and the Air Force, like F-16s, to the joint purchase of the F-35 Joint Strike Fighter.

Requirements Generation

The requirements generation process establishes the collective intent of the government on what weapon systems are purchased. Requirements generation operates in conjunction with the Planning, Programming, Budgeting, and Execution (PPBE) process used to manage resources by applying constraints. While internal to the government, requirements generation is visible to industry and provides information on the future intent of the government-buying preferences. Government selection and procurement of given weapon systems is not independent of evolving technology.

The number of aircraft ultimately purchased has fallen as technological advances deliver additional capability. For example, by 1958, when the F-4 fighter prototype first flew (Smith & Friedman, 1980), the speed of fighter aircraft reached a plateau and technology changed to focus on guided missiles, which represented a growing percentage of aerospace industry sales and in many cases were viewed as a substitute for aircraft (Simonson, 1968). The increased capability of aircraft from technology advances, such as guided weapons, simply translated into a requirement for fewer numbers of aircraft. For example, the impact is clearly demonstrated in comparing U.S. Air Force procurement quantities of F-4 aircraft (2,600) to F-117 stealth fighters (59). However, the resulting capability is comparable in that a single F-117's bombing effectiveness equates to 95 F-4 aircraft

"The number of aircraft ultimately purchased has fallen as technological advances deliver additional capability"

(Toffler & Toffler, 1993). The general impact of available technology delivering more capable weapon platforms suggests fewer major defense firms were needed (Deutch, 2001). Additionally, an increased emphasis on jointness has led to the Joint Strike Fighter becoming the single planned replacement aircraft for the Air Force's F-16, the Navy's F/A-18, and the Marine's AV-8B.

Further decreasing the number of different aircraft designs, the trend in requirements generation has been toward joint programs, or programs that meet the needs of more than one armed service. Emphasis on joint weapon programs has steadily increased since the F-111 aircraft was originally designed to meet the needs of two services—the Air Force and Navy (Smith & Friedman, 1980). Among other initiatives, the Goldwater-Nichols Department of Defense Reorganization Act of 1986 made the Joint Chiefs of Staff advocates for a joint military perspective with the vice Chairman of the Joint Chiefs of Staff (VCJCS) responsible for chairing the Joint Requirements Oversight Council (JROC), a special council on military requirements (Owens, 1994). After the termination of the Navy's A-12 aircraft program, in 1991, joint programs took hold as the dominant paradigm as the termination essentially ended service- and mission-unique aircraft programs (Jefferson, 1991). The emphasis on joint programs has also increased the monopsony power of the government as procurement is further centralized from the different armed services.

"Another consideration is that each aircraft program essentially involves a *'winner take all'* competition for manufacturers."

Another consideration is that each aircraft program essentially involves a *"winner take all"* competition for manufacturers. The most recent fighter aircraft competition involved the Joint Strike Fighter (JSF), and the associated development contract was awarded to Lockheed-Martin and Boeing in November 1996 (*Wall Street Journal*, 1996a). One month later, after just ending similar merger discussions only six months earlier, Boeing announced a merger with McDonnell Douglas, the loser of the JSF competition (*Wall Street Journal*, 1996b). The *only* change in prospects for McDonnell Douglas, after it scuttled merger discussions with Boeing earlier the same year, was the JSF contract award. As the JSF represented the only major fighter aircraft contract anticipated for at least a decade, consolidation represented a reasonable reaction. The JSF program also demonstrates the level of emphasis on joint programs. The JSF is the planned replacement for the Navy F/A-18, Air Force F-16 and Marine AV-8B aircraft, plus aircraft for several foreign military partners that are participating in the program. Maturing technology, winner take all competitions, and increased emphasis on joint programs all contributed to fewer aircraft programs that, in turn, drove consolidation as each factor signaled a requirement for fewer aircraft manufacturers.

Government Organization

The most existing literature on the defense industry overlooks the organization of government agencies. However, due to

the interaction between government and defense contractor offices, changes to the structure of government procurement organizations also impacts defense firms. Procurement organizations have undergone two primary changes—centralization and downsizing.

The centralization of procurement policy and intervention by Congress through the Goldwater-Nichols Department of Defense Reorganization Act of 1986, created consistent government procurement oversight by establishing Program Executive Officers (PEOs). The PEO structure for the majority of procurement programs established a streamlined authority through the civilian leadership from the Service Acquisition Executive (SAE), the most senior service official for acquisitions of weapon systems, to each weapon system program manager. This change lessened the influence of other varied organizations in the DoD and respective services from the day-to-day operations of weapons system procurement.

Reduced defense budgets have placed an emphasis on downsizing of government procurement agencies that are largely viewed as ancillary to the armed services mission of winning wars. Traditionally government program offices issued various contracts to different prime contractors for different subsystems of an overall weapon system and the government acted as the integrator. However, reduced personnel resources following the end of the Cold War led to government program offices placing more effort on contract, resulting in a migration of tasks and associated transactions from the government to defense firms acting as prime contractors.

This migration of responsibility was generally known as Total System Program Responsibility (TSPR). Under this concept a defense firm selected as the prime contractor for a program was given this "total responsibility" under broad integration contracts. The prime contractor is now often responsible for integration of an overall system, instead of the government's weapon system program office. Increased responsibility by prime contractors had the effect of limiting the number of contracts available from the government as subsystem contracts previously issued by the government were bundled within a prime contractor's weapon system contract. The combined effects of centralization and downsizing led to a shift in workload from government-buying agents to prime defense contractors, and reduced government unique transaction costs with the market. The competitive impact of this shift in subcontract management from the government to defense firms is unknown, and represents an opportunity for future research.

"Reduced defense budgets have placed an emphasis on downsizing of government procurement agencies that are largely viewed as ancillary to the armed services mission of winning wars."

While the number of government procurement personnel has decreased, there was increased emphasis on ensuring they were better trained. Congress passed the Defense Acquisition Workforce Improvement Act (DAWIA) in 1990, and it outlined education and certification procedures for a professional procurement workforce. Centralization of procurement policies was followed by centralization of training, and in 1992 Defense Acquisition

University (DAU) was formed. The consolidation of the training for government personnel on the unique institutional mechanisms and structures further demonstrated government procurement policy centralization that was helping to prompt defense industry consolidation. The consolidation of processes would only be strengthened as government procurement personnel received training on uniform procurement practices from a centralized training organization.

Summary

Forces relating to changing technology and changing government institutional practice corresponded with decreased defense spending to drive defense industry consolidation. Changing government practice includes joint procurement, centralization of procurement policy, standardization of government procurement organization, and standardized training of a core of professional procurement personnel. Together these evolving changes led to common government policies that changed the dynamic in the defense industry and pressured defense firms to reduce transaction costs through consolidation. Viewing the defense industry consolidation using this framework provides a more complete explanation than reduced defense spending. The framework also provides a better foundation for future policy recommendations.

"Together these evolving changes led to common government policies that changed the dynamic in the defense industry and pressured defense firms to reduce transaction costs through consolidation."

Discussion

The central message of this paper is that the U.S. government holds a unique position in the defense industry as both a monopsony customer and as a federal government with regulatory oversight that controls the mechanisms in the market. This position allows the government to have a hyper influence on the institutions governing the mechanisms of exchange and thus the structure of the defense industry. Evolving government policies and their impact on transaction costs (North, 1990) brings clarity to explaining recent defense industry consolidation.

Our observations are consistent with views of institutions impacting transaction costs and the structure of markets. We find that both government procurement organizations and defense firms should be viewed as rationally reducing transaction costs and thus the structure of the defense market. The defense industry experiences a unique set of transaction costs from those experienced in commercial-oriented free markets, and the application of competitive market prescriptions focused on prices to the defense industry is inappropriate.

An institutional framework that considers transaction costs provides a more complete picture for moving forward and assessing defense industry efficiency issues that concern policy makers. The current view commonly held within the government and the literature focuses on competition driving defense industry efficiencies and preventing defense firms from collecting monopoly rents. This view is derived from traditional supply and demand models with multiple suppliers and customers and has less application considering the unique nature of the defense industry. For example, the Truth in Negotiation Act

(TINA) of 1962 and creation of the Defense Contract Audit Agency in 1965 (Lorell, *et al.*, 2000) has created a system where the government provides a counterbalance to any monopoly power, ensuring it only pays fair and reasonable costs for products.

The changes in the defense industry over the past 20 years represent the government and firms rationally reducing transaction costs through centralization and consolidation respectively, but not a substantial increase use of free market mechanisms. It is unlikely that the defense industry will ever approximate a competitive market, as long as the government remains a monopsony customer with regulatory oversight.

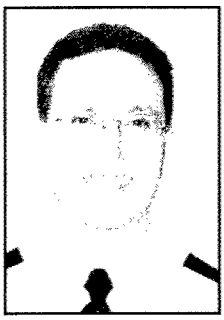
Any application of a competitive market framework will shed limited light on the realities of defense industry structure and its evolution. We show that expanding the view of the defense industry to include institutions and related transaction cost provides improved explanation for observed defense industry phenomenon, or in the present case industry consolidation. Institutions and transaction costs can provide a more realistic framework for economic analysis, and should play a more active role in framing policy recommendations.

The defense industry is typically characterized as inefficient. However, determining the efficiency of a market needs to consider constraints imposed by transaction costs, and an outcome without a feasible and superior alternative should be accepted as efficient (Williamson, 1985). The *feasibility* of alternatives needs to be understood within the institutions relating to a market, or relevant legal, economic, and political realities, which in the case of the defense industry, play a larger role than a traditional competitive marketplace. For activities in the public sector, external costs imposed on the operation of markets may be higher than necessary—reducing these costs requires modifying the institutions governing decision-making heuristics (Buchanan & Tullock, 1962). Indeed, the preoccupation with rational choice and efficient market often blind people to the implications of complex environments and the realities of incomplete information (North, 1999). Recognizing path dependence is key to understanding long-run economic change, and our review shows the additional forces that evolving government institutions placed on defense firms likely contributed to consolidation.

In closing, reduced defense spending alone does not fully explain the consolidation of defense firms witnessed during the 1990s, as decreased defense spending has occurred in the past without similar consolidation. The unique nature of the defense industry makes the application of traditional price driven explanations and associated policy recommendations from competitive markets tenuous. Examination of the interaction of evolving technology, changing institutions, to include the procurement policy, weapons requirements process, and the procurement organizations on transaction costs in the defense industry will more fully explain the forces driving consolidation and provide greater insight for policy makers seeking to improve the performance of the defense industry. Further research is needed to develop a robust institutional framework of the defense industry and the related government agencies.

ENDNOTE

1. Even Foreign Military Sales (FMS) typically are handled through the DoD, or U.S. government.



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References

Anderson, P., & Tushman, M. L. (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. *Administrative Science Quarterly*, *35*(4), 604–633.

Augustine, N. (1997). Reshaping an industry: Lockheed Martin's survival story, *Harvard Business Review*, *75*(3), 83-94.

Birkler, J., Bower, A. G., Drezner, J. A., Lee, G., Lorell, M., Smith, G., Timson, F., Trimble, W. P. G., & Younossi, O. (2003). *Competition and innovation in the U.S. fixed-wing military aircraft industry,* Santa Monica, CA: RAND.

Chu, S. C. & Waxman, M. C. (1998) Shaping the structure of the American defense industry. Gerald & O'Keefe (Eds.), *The defense industry in the post-Cold War era: Corporate strategies and public policy perspectives.* New York: Pergamon.

Commission on the future of the United States Aerospace Industry (2002). Commission on aerospace delivers final report and findings to President Bush and Congressional leaders concerning air transportation, homeland defense, and space sector health: Nine comprehensive recommendations for action issued, Arlington, VA.

Deutch, J. (2001). Consolidation of the U.S. defense industrial base, *Acquisition Review Quarterly*, *8*(3), 137-150.

Ferrara, J. (1996). DoD's 5000 documents: Evolution and change in defense acquisition policy, *Acquisition Review Quarterly*, *3*(2), 109-130.

Furubotn, E. G., & Richter, R. (1998). *Institutions and economic theory: The contribution of the new institutional economics,* Ann Arbor, MI: The University of Michigan Press.

Greenwood, R., & Hinings, C. R. (1996). Understanding radical organizational change: Bringing together the old and new institutionalism, *Academy of Management Review*, *21*(4), 1022-1054.

Jefferson, D. J. (1991, March 20). McDonnell has loss estimate for A-12 job — Program cancellation could cost added $850 million if legal challenge fails, *Wall Street Journal*, B.4.

King, D. R., Covin, J. G., & Hegarty, W. H. (2003). Complementary resources and the exploitation of technological innovations, *Journal of Management*, *29*(4), 589-606.

King, D. R., & Driessnack, J. D. (2003). Investigating the integration of acquired firms in high-technology industries: Implications for industrial policy, *Acquisition Review Quarterly, 10*(2), 261-284.

Langlois, R. N., & Robertson, P. L. N. (1995). *Firms, markets and economic change*,: New York: Routledge.

Lorell, M. A. & Levaux,. H. P. (1998). *The cutting edge: A half century of U.S. fighter aircraft R&D*. Santa Monica, CA: RAND.

Lorell, M. A., Lowell, J., Kennedy, M. & Levaux, H.. (2000). *Cheaper, faster, better? Commercial Approaches to Weapons Acquisition*. Santa Monica, CA: RAND.

Markusen, A. (1998). The post-Cold War persistence of defense specialized firms. In Gerald, I. & O'Keefe, S. (Eds.), *The Defense Industry in the Post-Cold War Era: Corporate Strategies and Public Policy Perspectives*. New York: Pergamon.

McNaughter, (1989). *New weapons old politics, America's military procurement muddle*. Washington DC: The Brookings Institution.

Nagle, J. F. (1999). *History of government contracting*. Washington DC: The George Washington University.

North, D. C. (1999). *Institutions, institutional change and economic performance*. Cambridge, United Kingdom: Cambridge University Press.

Owens, W. A. (1994, Summer). JROC: Harnessing the revolution in military affairs. *Joint Forces Quarterly*. Retrieved March 9, 2004 from http://www.dtic.mil/doctrine/jel/jfq_pubs/jfq0905.pdf

Peck, M. J., & Scherer, F. M. (1962). *The weapons acquisition process; an economic analysis*. Boston, MA: Harvard University.

Przemieniecki, J. S. (1993). *Acquisition of Defense systems*, Washington, D.C.: American Institute of Aeronautics and Astronautics: 13-15.

Ricks, T. E. (1996, December 17). Deal would test Pentagon policies about competition, *Wall Street Journal*, A.3.

Rogerson, W. P. (1994). Economic incentive and the Defense procurement process, *The Journal of Economic Perspectives*, *8*(4), 65-90

Sapolsky, H. M., & Gholz, E. (1998, May 21). How about an antitrust probe of the Pentagon? *Wall Street Journal*, A.1.

Simonson, G. R. (1968). Missiles and Creative Destruction in the American Aircraft Industry, 1956-1961, in *The History of The American Aircraft Industry*, edited by G.R. Simonson. Cambridge, MA: MIT Press.

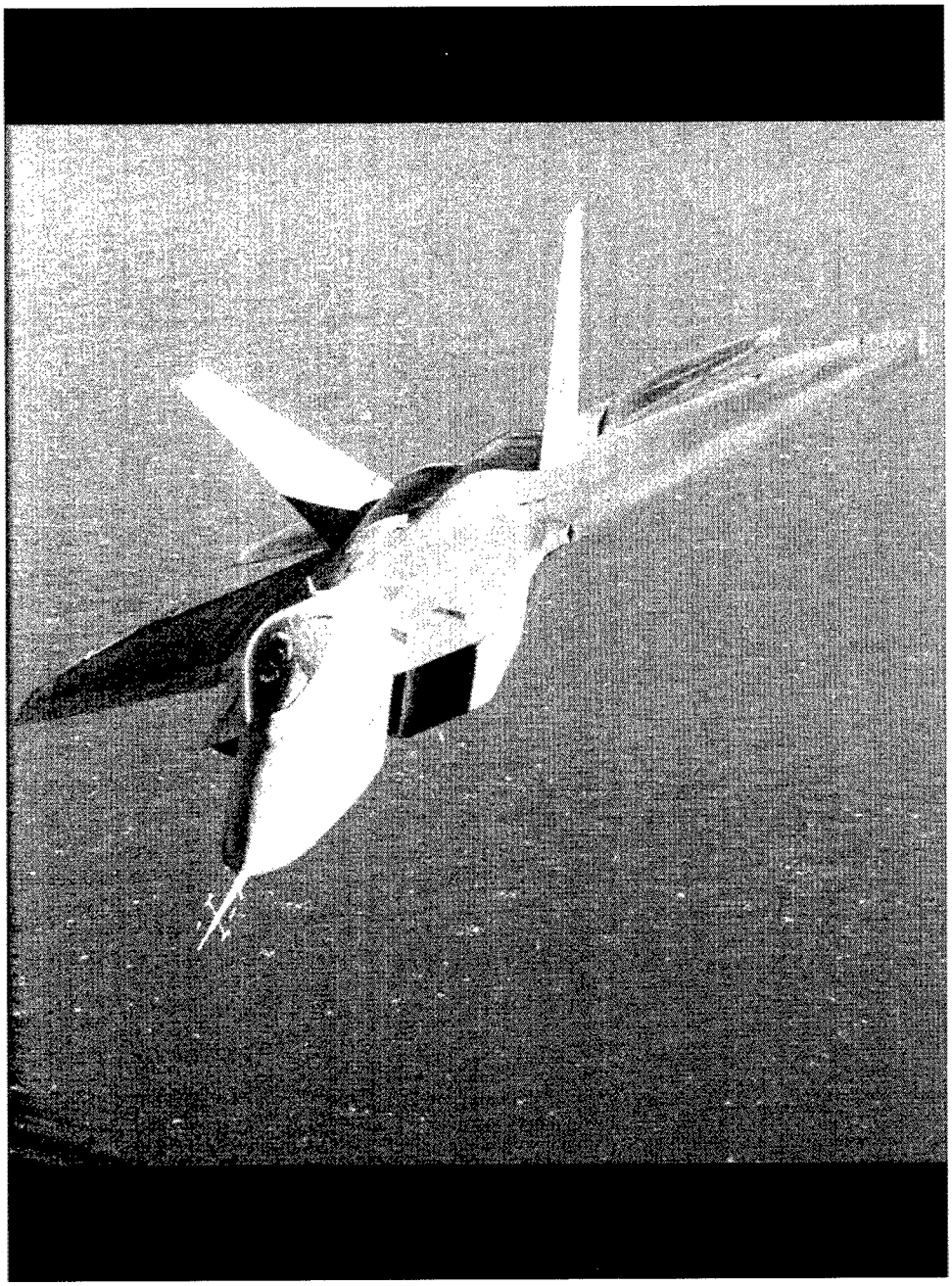
Toffler, A., & Toffler, H. (1993). War and anti-war: Survival at the dawn of the 21st century. Boston, MA: Little Brown and Company.

Business and Finance. (1996a, November 18). *Wall Street Journal*, A.1.

Business and Finance. (1996b, December 16). *Wall Street Journal*. A.1.

Williamson, O. E. (1985). *The economic institutions of capitalism: Firms, markets, relational contracting*. New York: The Free Press.

Williamson, O. E. (1996). *The mechanisms of governance*. New York: Oxford University Press.



SURVEYING COST GROWTH

Maj Michael Greiner, USAF, Capt Vince Sipple, USAF, and Maj Edward "Tony" White, USAF

Cost growth that weapon systems incur throughout their acquisition life cycle concerns those who work in the acquisition environment. One way to reduce the amount of unexpected cost growth is to develop better cost estimates. In attaining better cost estimates though, it is often helpful to understand and account for potential cost drivers. Several cost studies, some of which specifically focus on the aircraft industry, have been performed documenting and investigating these growth factors. Overviews of these various cost growth studies are presented as other tools for the cost estimators and program managers.

The cost growth that major weapon systems incur represents a major management challenge. A 1993 study by RAND cites that by the time a Department of Defense (DoD) Acquisition Category (ACAT) I program completes the production and fielding phase of acquisition, it will experience an average cost growth of approximately 20 percent from its initial estimate (Drezner, Jarvaise, Hess, Hough, & Norton, 1993).

During the early eighties, the Reagan administration recognized two ways to control the problem of cost growth — perform cost/requirements tradeoffs when costs grow and create better estimates (Office of the Under Secretary of Defense, 1981). Since then, high-level DoD management personnel continue to seek better ways of controlling cost growth.

While program managers shoulder the burden of controlling cost growth, the second method promoted by the Reagan administration for addressing cost growth, creating more realistic estimates, pertains more directly to the cost estimating community (Office of the Under Secretary of Defense, 1981). The impediments to creating more realistic estimates primarily stem from the many uncertainties that estimators encounter during their data collection efforts. The Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG) gives guidelines for documenting cost estimating uncertainty for DoD system acquisition programs.

First, they mandate that "areas of cost estimating uncertainty will be identified and quantified" (Department of Defense [DoD], 1992, p. 22). Programs must document this uncertainty in the Cost Analysis Requirements Document (CARD). Second, the CAIG prescribes

"the use of probability distributions or ranges of cost" to quantify uncertainty (DoD, 1992, p. 22). Third, they ask that the uncertainty estimated be "attributable to estimating errors" (DoD, 1992, p. 22). For instance, they list as such examples, performance and weight characteristics, new technology, manufacturing initiatives, inventory objectives, schedules, and financial condition of the contractor.

DoD procedures also provide for contingency estimation and sensitivity analysis, giving the estimator the option to either include or exclude a contingency amount. If the estimator includes contingency amount, he must give the reason for the contingency estimate as well its rationale. In addition, he must "include an assessment of the likelihood that the circumstances requiring the contingency will occur" (DoD, 1992, p. 22).

To better address uncertainty in the estimating process, the defense department sponsors much research. For this article's preparation, we reviewed past growth studies in the literature and highlight those here

Table 1. Consolidated Results of Reviewed Studies

Study	Main Findings
BMDO	• Average RDT&E cost growth is 21%. • Average Production cost growth is 19%. • Only 7 to 16% of programs complete at or below target cost. • Programs with lower dollar value have greater likelihood of cost growth.
RAND	• On average smaller programs have more cost growth. • RDT&E funds tend to experience more cost growth than production funds. • Programs maturity affects cost growth. Longer implies greater likelihood. • New-start programs over modification programs have more cost growth.
NAVAIR	• Cost growth varies across different cohorts (grouped by different estimate categories). • No statistical significance in overall cost growth due to program size. • Acquisition changes since the end of the Cold War have lead to less cost growth. • Cost growth may vary by commodity.
CHRISTENSEN & TEMPLIN	• Management reserve budgets sensitive to contact category (fixed-price higher than cost reimbursable). • MR budgets do not differ between production and RDT&E contracts.
ESKEW	• Weight, speed, production rate, and time explain more than 90 percent of the variation in cost growth of fighter aircraft.
IDA	• Urgency of the program, difficulty of technology, and degree of testing affect cost growth. • A relationship between cost growth and schedule growth in both the development and the production phases exist.
RAND-JSF	• Differences between the competitive and non-competitive development and procurement cost growth factors are not statistically significant.

that we feel provides the cost estimating community with an overall synopsis of available research. We list and explain those in detail in the remaining sections. For ease of review we have summarized their major findings in Table 1.

Studies of Cost Growth in DoD Acquisitions

Ballistic Missile Defense Organization Study

A recent Ballistic Missile Defense Organization (BMDO) cost growth study provides insight into the nature of cost growth in DoD programs. Using an internal BMDO database of programs (created from a subset of the Selected Acquisition Report [SAR] database), BMDO finds that Research and Development, Test, and Evaluation (RDT&E) cost growth averages 21 percent while that of production averages 19 percent (Coleman, Summerville, DuBois, & Myers, 2000). The study also shows that from 7 to 16 percent of programs complete at or below the target cost. Additionally, data from the study suggests that the lower the dollar value of a program, the greater likelihood of a large cost growth factor. Despite this trend, though, the authors do not provide any statistical tests to explore this possibility.

The BMDO researchers further note that as a program progresses, cost estimators revise their estimates, thereby reducing the amount of estimated risk and increasing the amount of realized risk. Under the assumption of unbiased risk estimates, one expects realized risk to equal estimated risk on average, given a large sample. However, the study shows that the risk portion of the estimate decreases more slowly than the rest of the estimate increases. This evidences a general trend of underestimating risk (Coleman et al., 2000).

RAND Study (1993)

The study canvassing an extensive array of information is arguably that of over 100 data points performed by RAND. Like the BMDO study, RAND uses data from the SAR reports, and RAND focuses on the seven categories of cost variance that the SAR contains: quantity, economic, schedule, engineering, estimating, support, and other. In this study, RAND finds that economic and quantity changes have the greatest impact on cost growth. However, RAND excludes them from their study because these two factors are part of the assumptions of a cost estimate initially.

The RAND study goes on to relay several other factors that relate to cost growth. Like the BMDO study, RAND finds an apparent difference in cost growth based on program size. That is, smaller programs have on average more cost growth than larger ones. The RAND researchers postulate as the reason behind this difference the greater level of management scrutiny that higher dollar programs receive. This stands to reason considering more management scrutiny should translate into better cost management.

"data from the study suggests that the lower the dollar value of a program, the greater likelihood of a large cost growth factor."

The authors of the RAND study offer another possible explanation for the difference in cost growth of the smaller programs, "R&D costs are a large portion of total costs and tend to incur more cost growth" (Drezner et al., 1993, p. 49).

In other words, smaller programs are disproportionately smaller in procurement than in RDT&E. Since RDT&E funds tend to experience more cost growth than procurement funds, the same percent RDT&E cost growth in a smaller program pushes the overall program percentage cost growth higher than a large program counterpart.

Program maturity also factors largely in program cost growth. The RAND study notes that "on average, cost growth increases by 2.2 percent per year above inflation because of the effects of maturity" (Drezner et al., 1993, p. 49). RAND emphasizes the importance of these two factors above other factors in the statement, "program size and maturity can dominate other factors affecting cost growth outcomes and so must be considered in both the analysis and the interpretation of results" (Drezner et al., 1993, p. 49).

"While the prototyping probably does significantly reduce risk, it apparently does not reduce it to the extent that would make a prototyped program have less cost growth than a non-prototyped program."

The RAND study elucidates the impact of new-start programs versus modification programs, finding that on average, the new-start programs experience more cost growth than modification programs. The RAND study also finds longer programs to have more cost growth than shorter ones. This relationship proves intuitive: each year brings the opportunity for more cost growth. Interestingly, they find no relationship between planned length and cost growth nor between schedule slip and cost growth (Drezner et al., 1993).

Finally, RAND finds a correlation between prototyping and cost growth:

> We compared the cost outcomes of prototyping and nonprototyping programs, expecting to find that a prototype development strategy contributes to cost control through reduction of uncertainty. Interestingly, programs that included prototyping had a relatively higher cost growth. This result may be due in part to the timing of the prototype phase within the context of the overall program schedule, since earlier prototyping makes data available earlier, thus potentially affecting the baseline cost estimate at the time of EMD start. Our results are consistent with this notion. It may also be true that prototyping was conducted for programs with relatively higher degrees of technical uncertainty, a hypothesis that deserves further exploration. (Drezner et al., 1993, p. 51)

Given that DoD prescribes risk reduction such as prototyping for riskier programs, RAND's assessment rings true. While the prototyping probably does significantly reduce risk, it apparently does not reduce it to the extent that would make a prototyped program have less cost growth than a non-prototyped program.

NAVAIR Study

Naval Air Systems Command (NAVAIR) presents its most recent study on cost growth at the 2001 DoD Cost Analysis Symposium, corroborating some of the results of previous studies.

Here again, SAR data are used. As part of their analysis, they explore the possible need for "cohort tracking" when analyzing cost growth (Dameron, Pullen, Summerville, Coleman, & Snead, 2001).

By *cohort tracking*, the NAVAIR team refers to the grouping of cost growth according to certain programmatic characteristics that relate to common patterns of cost growth. The team divides program cost growth into five categories or cohorts — RDT&E cost growth for programs with a planning estimate (PE) and a development estimate (DE); RDT&E cost growth for programs with a DE only; procurement cost growth for programs with a PE, a DE, and a production estimate (PdE); procurement cost growth for programs with a DE and a PdE only; and procurement cost growth for programs with a DE only (Dameron et al., 2001).

The three different estimates (PE, DE, and PdE) are the baseline estimates that correspond to each of the major decision points in Milestone A, B, and C respectively. NAVAIR uses the five cohorts consisting of the different types of estimates to categorize the cost growth, because the use of those mixes of cost estimates relate to different types of program structures, which might represent distinct populations with distinct cost growth patterns.

After looking at 318 DoD programs, the cohort study results show that the PE and DE cohort has an average of 30 percent RDT&E cost growth; the DE-only cohort has an average of 25 percent RDT&E cost growth; the PE, DE, and PdE cohort has an average of 35 percent procurement cost growth; the DE and PdE cohort has an average of 25 percent procurement cost growth; and the DE-only cohort has an average of 15 percent procurement cost growth. The sample sizes are 25, 140, 6, 53, and 94 respectively (Dameron et al., 2001). The NAVAIR group indicates that the "results are tentative," but their findings suggest differences in cost growth from one cohort to another.

In particular, they point out that, in their study, "programs with a Program Definition and Risk Reduction (PDRR) phase have more growth" (Dameron et al., 2001, p. 11). The purpose of PDRR is to reduce risk, so programs with PDRR naturally have a lot of uncertainty, and quantifying the costs of such a program should be more difficult than for less risky programs. In addition, the natural correlation between programs with a PDRR phase and programs with a prototyping effort, leads one to expect similar results as the two relate to cost growth. Finally, programs with a PDRR phase tend to have a longer RDT&E funding year stream than those without PDRR. This meshes with RAND's finding that longer programs tend to have higher cost growth. Thus, consistency exists in the findings showing that programs with risk reduction efforts tend toward higher cost growth.

"By *cohort tracking*, the NAVAIR team refers to the grouping of cost growth according to certain programmatic characteristics that relate to common patterns of cost growth."

The NAVAIR study also analyzes cost growth correlations between program phases and between the RDT&E and procurement appropriations. The study finds a significant correlation between RDT&E cost growth in the PDRR phase

and RDT&E cost growth in the EMD phase and also finds "significant correlation between procurement growth during the EMD and production phases" (Dameron et al., 2001, p. 14). Finally, the study uncovers a significant correlation between appropriations such that, during EMD, when the RDT&E appropriation experiences cost growth, so does the procurement appropriation (Dameron et al., 2001).

As a third area of study, the NAVAIR group analyzes how program size affects cost growth. Unlike the BMDO and RAND studies, the NAVAIR team performs statistical comparisons that reveal that high and low dollar programs have identical distributions despite "a trend of more high end extrema in the smaller size classes" (Dameron et al., 2001, p. 21). To explain the difference in the extrema, they reason that, "high risk programs may be terminated earlier if large, but tolerated if small" (Dameron et al., 2001, p. 21). Thus, inferential statistics suggests no difference in the overall cost growth based on size.

"NAVAIR's results suggest that acquisition changes since the end of the Cold War lead to less cost growth."

Next, NAVAIR studies the effects of the era in which an acquisition terminates. The team uses "DoD programs with DE only from the RAND 93 dataset, NAVAIR programs with DE only from the SAR 00 dataset, and NAVAIR programs with DE only from the Contract dataset (RDT&E only)" (Dameron et al., 2001, p. 23). Thus, they use three separate data sets, two of their own compilation and the RAND 93 dataset. The group studies the effects of two eras — pre–1986 and post–1986. They choose 1986 as a dividing point, because that year marks the last year of the Reagan arms buildup (Dameron et al., 2001). The team performs *t*-tests to determine if the two eras differ statistically. They find the following results:

- RAND 93: The means of programs through 1986 and those after 1986 did show a statistical difference for RDT&E, but not for procurement.
- SAR 00: The means of programs through 1986 and those after 1986 did show a statistical difference for procurement, but not for RDT&E.
- Contract: The means of programs through 1986 and those after 1986 did not show a statistical difference for RDT&E. (Dameron et al., 2001, p. 31)

The team concludes that their "analysis supports a decline in cost growth factor (CGF) over time" (Dameron et al., 2001, p. 32). They mention that these results differ from previous studies perhaps because of differences in the number of data points or dates of era division (Dameron et al., 2001).

NAVAIR's results suggest that acquisition changes since the end of the Cold War lead to less cost growth. Although difficult to pinpoint the reason for this decline in cost growth, logic leads to candidate scenarios. The draw-down in military spending after the Cold War produces an environment in the government where meeting cost goals becomes more important for program survival. So perhaps the ensuing emphasis on better estimating improves base-line estimates from which cost growth is measured.

Improvements in the estimating profession might also play a part in improving base-line estimates.

NAVAIR also studies differences between commodities and their relation to cost growth. The team looks at all three databases, but limits the data to 20 RAND 93 programs, 11 SAR 00 programs, and 21 contract data programs. They conclude that missile programs experience higher cost growth during RDT&E than either electronic or aircraft programs. This result suggests that cost growth may vary by commodity.

The NAVAIR team further compares RDT&E cost growth in small programs (less than one billion dollars in RDT&E) as portrayed through the SAR 2000 data versus the NAVAIR contract database. Their analysis shows that the results from the two databases do not significantly differ (Dameron et al., 2001). They conclude that potential exists to use either database to study cost growth. Intuitively, cost growth from a contract only perspective mirrors that of an overall program cost perspective, because the vast majority of program dollars apply to contracts.

Christensen and Templin Study

David Christensen and Carl Templin research cost growth using the Defense Acquisition Executive Summary (DAES) database and arrive at potentially useful findings in the search for predictors of cost growth. The DAES database contains contractor information organized according to the rules of Earned Value Management, a process by which the government monitors the cost and schedule performance of contracts against baseline figures (Christensen & Templin, 2000).

The researchers consider "hundreds of DoD defense acquisition contracts from 1975 through 1998" in a hypothesis testing scenario focused on the nature of management reserve (MR) budgets (Christensen & Templin, 2000). DoD characterizes an MR budget as "a reserve for uncertainties related to in-scope but unforeseen work" (DoD, 1997, p. 12). MR budgets, because they represent the contractors' assessment of risk for acquisition programs, can provide useful insight into the overall risk assessment that DoD uses in its budgeting process.

Christensen and Templin recognize that many factors affect the development of a contractor's MR budget, and that the "achievability of a budget depends on how the budgets are established" (Christensen & Templin, 2000, p. 195). Thus, overruns can vary depending on factors such as differing methods, abilities, and motivations of those who set the MR budgets (Christensen & Templin, 2000). A 1998 survey of 300 DoD risk analysis professionals (U.S. Aerospace Cost Risk Analysis Survey, 2000) supports this statement by displaying the following variety of perspectives on risk analysis extant within government and contractor circles.

"They [the team] conclude that missile programs experience higher cost growth during RDT&E than either electronic or aircraft programs."

- 27 percent of analyses perform the risk assessment separately from the cost estimate.

- 26 percent of program managers do not accept risk assessment at all, not even *slightly*.
- 32 percent of the risk assessments do not involve finance or estimating.
- 38 percent of cost risk analysts have received no training, either formal or informal.
- 44 percent of risk ranges are intuitive judgments, without historical data or guided-survey.
- 69 percent of variable distributions are triangular.
- 18 percent of unfavorable assessments are ignored, as managers *stay the course*.

In addition, Christensen and Templin (2000) note that contractors should provide greater MR budgets for riskier projects. The authors characterize the development phase of acquisition as more uncertain than the production phase, and they characterize price contracts as more uncertain than cost-reimbursement contracts (Christensen & Templin, 2000). From this awareness of the diversity of risk analysis, Christensen and Templin perform hypotheses testing to realize the following results:

> The amount of an MR budget is sensitive to contract category (cost-reimbursable versus fixed-price), and the managing service. With regard to contract category, the median MR percent on fixed-price contracts is significantly greater than the median MR percent on cost reimbursable contracts. This is consistent with the expectation that contracts with more risk to the contractor have a larger MR budget. We do not know why MR budgets differ across the three services. Possible explanatory factors include differences in the weapon systems purchased by each service, and the contractors that build the systems. (Christensen & Templin, 2000, p. 204)

With regard to the acquisition phase, the researchers do not find that the MR budget differs between production and RDT&E contracts (Christensen & Templin, 2000). Christensen and Templin (2000) shed light into the way that contractors manage risk through MR budgets. The relationship between contract type and the MR budget stands to reason, since certain contract types place more risk on the contractor than others. The MR budget insensitivity to acquisition phase differs from the government's perspective that RDT&E efforts are more risky than procurement efforts; this difference reemphasizes the importance of using contract type to instigate contractor behavior that best advances government objectives. The sensitivity to managing service proves enigmatic. While possible that significant differences exist in the way each service manages its contracts, it may be that some other variable or variables, highly correlated with managing service triggers this sensitivity.

Cost Growth Specific to the Aerospace Industry

Eskew Study

To find the true rate of cost growth of fighter aircraft over time, Henry Eskew runs a multiple linear regression of 17 tactical aircraft from 1950 through 1980 (Eskew, 2000). He normalizes his data for production quantity by using the estimated 100th production unit cost, and he normalizes his data for inflation by applying the appropriate DoD inflation indices to convert his data to constant year (CY) 1990. Using the logarithm of cost as his response variable, he finds weight, speed, production rate, and time as statistically significant predictor variables that explain "more than 90 percent of the variation in cost" (Eskew, 2000, pp. 211–212). He also determines that, as a sole predictor, time explains about 40 percent of the cost variation (Eskew, 2000).

Although useful as a literature review, one must note some limitation of the Eskew study's applicability. First, the study looks at a limited amount of data from a limited perspective. It only considers tactical aircraft in its search for predictors, and it only has 17 data points. In addition, this research lacks currency, spanning the period from 1950 through 1980, and seeks to explain cost growth as overall increases in unit cost measured from previous programs over time (Eskew, 2000). Most of the research we consider heretofore considers cost growth within a single program over a much shorter time period.

Dr. Eskew (2000) seeks to dispel the myth that "no systematic relationship exists between the characteristics of an aircraft program and the length of its development cycle" (Eskew, 2000, p. 210). He uses the same normalization techniques mentioned earlier for inflation and quantity; however, he includes different aircraft, adding non-tactical fixed wing aircraft, and removing non-fixed wing aircraft (Eskew, 2000). The results of his 17 data-point regression show that unit flyaway cost predicts approximately 60 percent of the variance in the length of the development program: this predictive ability increases to 70 percent when a dummy variable is added indicating whether or not a program has inherited a significant amount of technology from a previous program (Eskew, 2000). Overall, the Eskew study highlights a correlation between aircraft physical and functional characteristics and production costs, and between program schedule and production costs.

"Overall, the Eskew study highlights a correlation between aircraft physical and functional characteristics and production costs, and between program schedule and production costs."

IDA Study

The Institute for Defense Analyses (IDA) performs an analysis on cost and schedule growth of tactical missiles and tactical aircraft in 1994 with the goal of finding patterns of cost growth and the reasons for the cost growth (Tyson, Harmon, & Utech, 1994). Within the group of 20 tactical missiles investigated, the IDA group finds that only two stay within their schedule, with one program slipping by as much as 180 percent. They also find that only two programs stay within budget, while the two

worst performers exceed their budgets by a factor of two (Tyson et al., 1994). The researchers of IDA examine the characteristics of the programs with the highest and lowest schedule and cost growth. From their study, they find that:

> [Missile] programs that employed a high degree of concurrency, that had to be dual-sourced for technical reasons or that were dual-sourced at less than full rate, had high cost growth. In one case, the threat of competition appeared to reduce costs. (Tyson et al., 1994, p. S-2)

The results from aircraft programs do not vary as much. The authors suggest closer management scrutiny and "protection from schedule stretch" as reasons for the more consistent cost growth in aircraft programs (Tyson et al., 1994, p. S-2). Two aircraft programs suffer elongated production schedules, but do not experience high production cost growth. The authors theorize that generally extending production incites cost growth; however, in these cases the existence of other DoD contracts cushions the impact of the adjusted schedules. The authors identify the F/A-18 as the program with the highest cost growth. They theorize that late engineering changes incite the high cost growth (Tyson et al., 1994).

The study considers whether modification programs have lower cost growth than new start programs. The one aircraft in their sample that is a modification does in fact experience low cost growth. The team finds that missile modification programs vary greatly in the cost growth they experience. They cite the fact that most missile modifications affect the expensive guidance and control system of the missile as a possible reason for this inconsistency (Tyson et al., 1994).

The researchers further find that the urgency of the program, the difficulty of the technology, the amount of concurrency, and the degree of testing all seem to affect cost growth (Tyson et al., 1994). From these results, the IDA researchers discover a relationship between cost growth and schedule growth in both the development and the production phases (Tyson et al., 1994). They find that quantity increases during development largely drive development schedule growth. The authors mention "the need to produce more items for testing than planned" as the reason for the increase in quantity (Tyson et al., 1994, p. S-6).

It is not clear whether failed tests drive the need to produce more test units or simply uncertainty in the planning process drove the need to produce more test units. Either way, one can draw a link back to technical risk from the need for more test units. The study also finds that whether a missile is an intercept missile and the length of the original schedule prove useful predictors of development schedule growth.

Lastly, the IDA study adds depth to the study of cost growth by using multiple regression to arrive at predictive formulas. Using multiple regression brings with it the benefit of taking into account the multi-dimensional interactions that independent variables have with dependent variables that can prove misleading in simple linear regression analysis and hypothesis testing.

RAND Study (2001)

In support of the Joint Strike Fighter (JSF) program, RAND studies the effect of competition on the amount of cost growth that occurs in both the RDT&E and procurement budgets (Birkler, Graser, Arena, Cook, Lee, & Lorell, 2001). The researchers analyze 14 programs that use competitive strategies and 44 programs that do not (Birkler et al., 2001). They find that "the results are mixed and the differences between the competitive and noncompetitive development [and procurement] cost growth factors...are not statistically significant at the 10-percent level" (Birkler et al., 2001, p. 80).

These results are potentially misleading, however, in that they represent a program-wide look, rather than a study of individual contracts. In other words, a program might be competitively awarded initially, but at a certain point in the string of contracts that make up a program one can make the case that a competitive environment no longer exists. Perhaps a study that compared individual contracts (rather than entire programs) might exact different results.

Conclusion

In this article, we document many studies that query different databases using various statistical methods in the effort to explain cost growth in DoD acquisition. We consider studies of overall DoD acquisition as well as studies that focus on a particular industry within the DoD acquisition landscape. Further research is currently being conducted to examine/investigate how best to model cost growth and which predictor variables should be included in such a model. From these, appropriate statistical tools and methodologies could then be made available to the cost community.

This article applies not just to the cost estimator, but also to the entire integrated process team. Knowledge of these studies should bring to bear a better understanding, a sharper focus, and a more efficient approach to those who seek to study cost growth in the future. It should also be clear to the estimator that more often than not, estimates will be low. From the many studies in this article, the estimator should find some insight that will lead him to a better analysis of risk to compensate in part for that tendency to underestimate. For the rest of the integrated process team, the reality is that cost overruns can kill programs.

As mentioned in the beginning of this article, the two sides of the solution coin are: more realistic baseline estimate (with accompanying risk dollars) and better cost control. Many hindrances might stand in the way of achieving more realistic estimates and better cost control. Those hindrances might be in the form of priority setting, manpower shortages, lack of training, budget cuts, requirement creep, or any number of other issues both foreseen or unforeseen. This article focused on providing decision makers in the acquisition world with some historical insight into what research has been done regarding cost growth. With knowing what has been in the past, it provides a roadmap to prevent rework as well as fine tune future research and promote ready-to-use analytical tools.

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References

Birkler, J., Graser, J. C., Arena, M. V., Cook, C. R., Lee, G., & Lorell, M. (2001). *Assessing competitive strategies for the joint strike fighter* (MR-1362-OSD). Santa Monica CA: RAND.

Christensen, D., & Templin, C. (2000, Summer). An analysis of management reserve on budget defense acquisition contracts. *Acquisition Review Quarterly, 7*(3), 191–207.

Coleman, R. L., Summerville, J. R., DuBois, M., & Myers, B. (2000, February 2). Risk in cost estimating: General introduction & the BMDO approach. Briefing at the 33rd annual DoD cost analysis symposium. Williamsburg, VA: Author.

Dameron, M. E., Pullen, C. L., Summerville, J. R., Coleman, R. L., & Snead D. M. (2001, April 24). NAVAIR cost growth: Overview of analysis. Briefing at the aeronautical systems center industry cost and schedule workshop. Wright-Patterson AFB, OH: Author.

Department of Defense. (1992, December). *Department of defense manual cost analysis guidance and procedures* (DoD 5000.4-M). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1997, October 3). *Earned Value Management Implementation Guide.* Washington, DC: U.S. Government Printing Office.

Drezner, J. A., Jarvaise, J. M., Hess, R. W., Hough, P. G., & Norton, D. (1993). *An analysis of weapon system cost growth* (MR-291-AF). Santa Monica CA: RAND.

Eskew, H. L. (2000, Summer). Aircraft cost growth and development program length: Some augustinian propositions revisited. *Acquisition Review Quarterly, 7*(3), 209–220.

Office of the Under Secretary of Defense, Department of Defense. (1981, December 23). *Final Report of the Task Force on Acquisition Improvement.* Memorandum for the Under Secretary of Defense for Research and Engineering. Washington, DC: Author.

Tyson, K. W., Harmon, B. R., & Utech, D. M. (1994, July). *Understanding cost and schedule growth in acquisition programs.* Institute for defense analyses paper P-2967 (AD-A284321). Ft. Belvoir, VA: Author.

U.S. Aerospace Cost Risk Analysis Survey. (2000, Winter). *National Estimator,* 23–32.

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LOGISTICS TRANSFORMATION
DELIVERING MATERIEL READINESS TO THE ARMY

From Collie Johnson, Editor-in-Chief, Defense AT&L

The Army's Office of the Deputy Chief of Staff, G-4, released in late December 2003 an Army Logistics White Paper, "Delivering Materiel Readiness to the Army," describing logistics shortfalls and near-term priorities.

"It's our strategic vision," said Lt. Gen. Claude V. (Chris) Christianson, Army G-4. "The paper's intent is to provide clear guidance where we want to take Army logistics in the next two years. It is tied directly to what we have experienced in the past few years."

For the benefit of our readers, the paper is presented here in its entirety. This summer, Defense AT&L will also be publishing an interview with Christianson that will focus on the logistics failures and successes he observed while serving as the principal Operation Iraqi Freedom logistics operator.

The Army G-4 exists to deliver materiel readiness to our Soldiers—a task that has remained the same for years. Today's operating environment has changed; we are an Army at War...relevant and ready. Our most critical task is to sustain the combat readiness of our Deployed Force and to maintain the operational readiness of the Current Force. The Current Force provides the warfighting readiness that serves our nation. The Current Force must adapt to a changing enemy and fight and win decisively against any threat. Our fundamental challenge within G-4 is to enhance our current capabilities while transforming Army Logistics for tomorrow. We will accomplish this vital task by focusing our efforts on four clear objectives.

This White Paper describes four G-4 Focus Areas we will hold preeminent over the next two years. It addresses known shortfalls in our current structure that require immediate action, and directly supports our Army's transition to an expeditionary force that is agile, versatile, and capable of acting rapidly and effectively. These Focus Areas are the Army G-4's highest priority, and we will apply our policies, processes, and resources to ensure success.

Focus Area #1– Connect Army Logisticians

Today's Army Logistician cannot see the requirements on the battlefield. Our customers cannot see the support that is coming their way. As a result, we rely on pushing support based on our best estimate of what we think the Soldier needs. Soldiers order the same item several times because they have no confidence support is on the way. We will solve this problem by connecting Army Logisticians. Army Logisticians will be an integral part of the joint battlefield network with satellite-based communications that provide 24/7 connectivity on demand, enabling them to pass and to receive key data from the battlefield to the industrial base. This connectivity will cover the battlefield, and it will provide Army Logisticians the agility and flexibility to quickly plug into and unplug from a dedicated network with an asynchronous (stand-alone) capability.

The G-4, along with the U.S. Army Materiel Command (AMC) and the U.S. Army Combined Arms Support Command (CASCOM), will work with the Chief of Staff of the U.S. Army (CSA) Task Force Network to ensure logistics communications solutions are embedded within the Army's network and will optimize joint and combined operations in an expeditionary environment. Our Enterprise Resource Planning work in Battle Command Sustainment and Support System (BCS3), Global Combat Support System– Army (GCSS-A), Logistics Modernization Program (LMP), and Product Life-cycle Management (PLM+) are critical to implementing fully this Focus Area from foxhole to factory to foxhole. The logistics common operating picture (LCOP) will be improved by this network connectivity, and it will provide the vital link in the joint commander's ability to see the force and to make decisions based upon accurate, real-time logistics information.

Focus Area #2 - Modernize Theater Distribution

Today's Army is not able to respond rapidly and precisely when support requirements are identified. We do not have the battlefield distribution system that we need. We cannot provide time-definite delivery schedules, and we cannot effectively control physical movements across the new battle environment. Effective theater sustainment rests solidly on the fundamental concepts of distribution-based logistics.

We need a single focus on the simple task of guaranteeing delivery—on time, every time. We must have a distribution system that reaches from the Soldier at the tip of the spear to the source of support, wherever that may be. Our success will be measured at the last tactical mile with the Soldier.

We will build warfighter confidence by increasing visibility and establishing flexible, responsive distribution capabilities. We will not need to store large quantities of supplies forward because we will respond to customer requirements with speed and precision. The G-4 will work with CASCOM and the U.S. Transportation Command, the DoD distribution process owner, to develop this solution from factory to foxhole in the joint environment. Along with AMC and the Defense Logistics Agency, we are committed to enabling an effective distribution-based sustainment process. We will work with the CSA Task Force Modularity to develop this objective in the near term.

Focus Area #3 – Improve Force Reception

We have invested heavily over the past 10 years in improving our ability to deploy rapidly from our continental U.S. platforms. The strategic movement of forces by Large Medium Speed Roll-On/Roll-Off (LMSR) vessels and C-17 aircraft has significantly enhanced our capabilities. However, we have not invested at the other end—in our ability to receive forces in the theater. We are hamstrung by the lack of an organizational construct that focuses on joint theater opening tasks. Today, we build ad hoc support organizations to execute aerial and sea port of debarkation operations, and we depend on forces from several organizations to establish the theater sustainment base. This process of receiving forces in theater takes time, a luxury we will not have as the Army develops an expeditionary structure that is capable of rapidly deploying joint-capable force modules.

In order to effectively facilitate the immediate operational employment and sustainment of the expeditionary force flow, we will design an integrated theater-opening capability that can respond on extremely short notice and can execute critical sustainment tasks immediately upon entry. That theater-opening capability will not be an ad hoc organization. It must be a support organization that has trained to the task. It must be enabled with the right tools to succeed, and it must have the capacity to expand to meet theater growth. The critical operational tasks for this organization include: (1) providing operational sustainment command and control with reach-back capability and initial network visibility; (2) conducting theater reception, staging onward-movement and integration operations, to include life support, force protection and port of debarkation operations; and (3) sustaining forces in theater with theater distribution and requirements visibility.

Focus Area #4 – Integrate the Supply Chain

Over the past several years the Army has taken supply reductions at many levels for various reasons. We changed Army policy several years ago to reduce the amount of items carried on unit prescribed load listings while simultaneously reducing stock levels in many authorized stockage lists across the field army. Additionally, we took risks at the strategic level by underfunding strategic spares programs. The cumulative result of these reductions is a lean supply chain without the benefit of either an improved distribution system or an enhanced information system. As a result, our Soldiers are at the end of a long line of communication with reduced inventories and an old distribution system.

We will view the supply chain in a holistic manner to ensure we understand the impact of actions across the entire chain, not just at a single level or within a single Service. This joint, end-to-end view is essential if we are to provide the kind of support our Soldiers deserve. The solution is an enterprise view of the supply chain, and an agency and a Service integration of processes, information, and responsibilities. We are committed to developing the Army's Enterprise Solution to the supply chain in close coordination and alignment with DoD's Focused Logistics Initiative. Ultimately, joint information will be freely and automatically shared among strategic, operational, and tactical-level headquarters and agencies. Consumers and logisticians from all agencies and Services will enter local supporting systems, plug into the sustainment network, and be afforded end-to-end joint total asset visibility (JTAV). As a result of our Theater Distribution efforts, combatant commanders will be capable of seeing inventory in motion, as well as seeing what is available at storage locations, and they will be able to rapidly and effectively execute decisions that meet their requirements.

Conclusion

We will build confidence in the minds of the combatant commanders by delivering sustainment on time, every time. We can do that only if we provide Army Logisticians the capability to see the requirements every day and to control the distribution to guarantee precise, time-definite support. Army Logisticians will be part of joint and combined logistics processes that increase speed to deliver focused logistics. We will integrate real-time total asset visibility and seamlessly connect to the industrial base. This will give us an LCOP that will enable the kind of end-to-end control that always delivers the right support to the exact location at the precise time needed. If we do not connect Army Logisticians, improve the capability of the distribution system, modernize force reception, provide integrated supply management and give the joint force combatant commanders JTAV, we will study these same lessons after the next major conflict. The Army G-4 is committed to ensure that we will not have to relearn these same lessons.

STAFF AND FACULTY FROM DEFENSE ACQUISITION UNIVERSITY RESPOND TO CRITICAL NATIONAL MISSION

Faculty and staff members from the Defense Acquisition University are providing ongoing support to the Iraq Program Management Office (PMO), a component of the Iraq Coalition Provisional Authority (CPA). The PMO was commissioned to provide oversight, management, and execution of the infrastructure reconstruction effects in Iraq. Under intense pressure to expedite award of the $18.6 billion supplemental appropriation—a mission they took on in November 2003—DAU team members Garry Shafovaloff, Linda Neilson, Lyle Eesley, Larry "Scoop" Cooper, and Bart Morrison have devoted countless hours and contributed considerable subject matter expertise to this critical national mission.

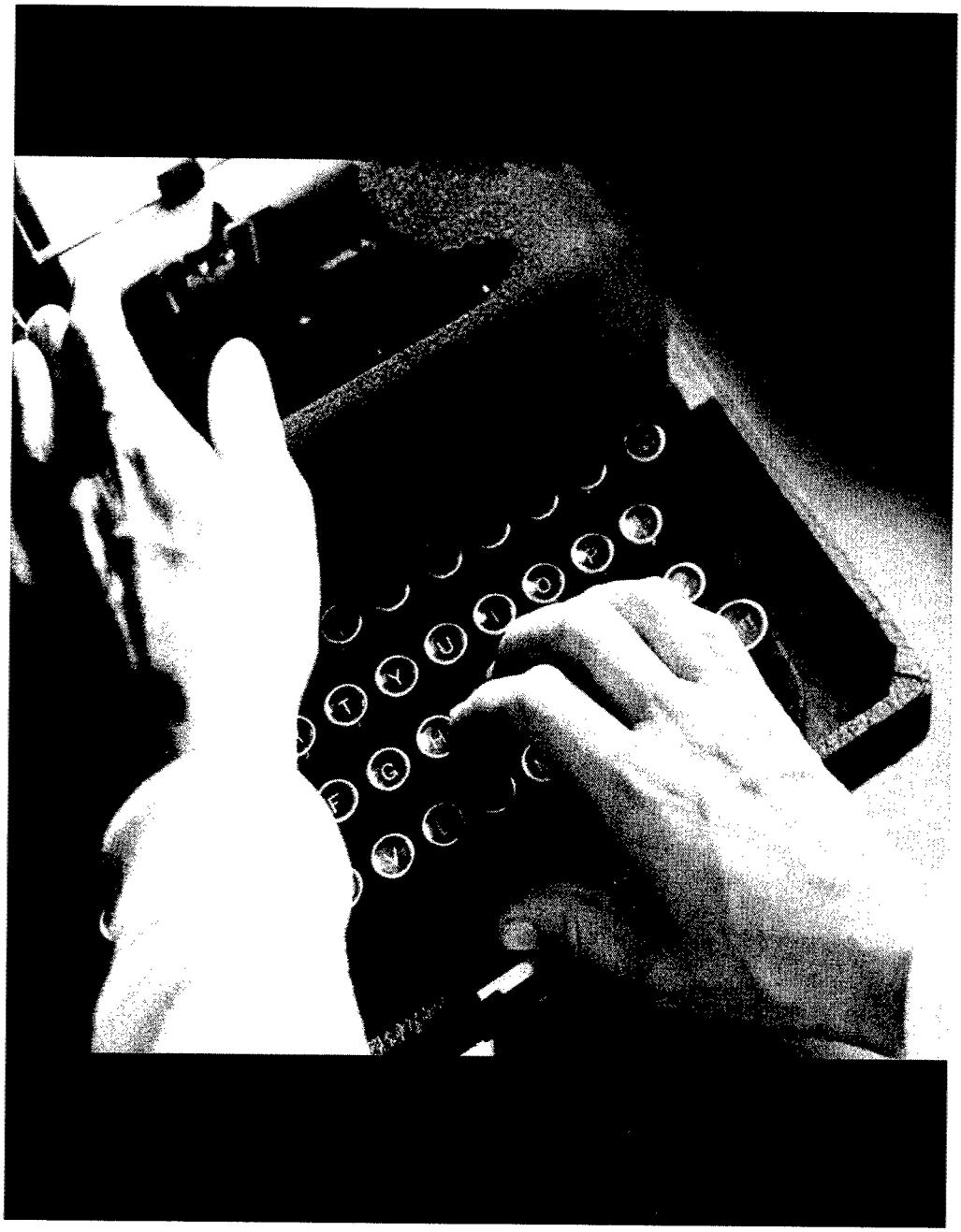
From the inception of the CPA-PMO, Deidre Lee, the Director of Defense Procurement and Acquisition Policy (detailed to the CPA for three months as Deputy for Operations), looked to Garry Shafovaloff and Linda Neilson to provide key leadership roles; craft innovative acquisition strategies; manage the coordination and integration of reconstruction project requirements with CPA-Baghdad and Office of the Secretary of Defense; resolve interagency development issues; respond to congressional inquiries; and coordinate policy with the White House. Eesley and Cooper continue to support the PMO and Sector PMO source selection process. Eesley also serves as the technical team chief for the source selection team. Morrison continues to provide support to the Construction Contracting Team serving as the lead knowledge management officer and workforce development specialist.

Army Sgt. Maj. Steve Gebert, DAU South Region, was activated for Operation Iraqi Freedom (OIF), and served as Kuwait Aerial Port of Debarkation (APOD) Operations coordinator from March to May 2003. From May to September he served as an action officer building daily and updated situation report briefings for the Central Command (CENTCOM) Regional General Staff, participated in those briefings, and worked distribution control and movement logistics actions. Since returning from OIF, Gebert has been involved in building an Operational Logistics Case Exercise based on his OIF experience for inclusion in LOG-304. He has also been working on an article identifying key logistics shortfalls, how they were overcome in the Iraqi War, noting what went well, and any recommendations for systemic change.

(continued on page 98)

During summer 2003, a DAU team provided exceptional performance support and rapid response to the Army's request for immediate instructional assistance for soldiers awaiting deployment orders, with an immediate need for training in both the CON-100 arena and in CON-234 (Contingency Contracting). Team members included Philip Deaton, DAU South; Ronald Fontenot, DAU South; Debbie Johnson, DAU Midwest; Air Force Maj. Michael McGhee, DAU Midwest; Air Force Lt. Col. Ralph Mitchell, DAU South; and Pamela Oxendine, DAU Midwest. In less than 21 days, this small team worked tirelessly to deliver a nine-day targeted training course that met the learning objectives of both courses in the constrained delivery time, while receiving high marks for quality and delivery from the warfighters.

Army Sgt. James W. Colbert, a member of the Video Services Department, Operations Group, DAU main campus, at Fort Belvoir, Virginia, was tasked with a critical assignment in support of the Iraq Infrastructure Reconstruction Office. Under intense pressure to deliver the finished product to soldiers awaiting deployment to Iraq, he edited, enhanced, encoded, and published over 20 hours of 18 separately recorded sessions of instruction in Contracting. Most notably, he did so in only four working days, receiving praise for the quality of his work and his efforts in delivering just-in-time training to the nation's warfighters.



LETTER TO THE EDITOR

HONEST PERFORMANCE ANALYSIS: *A NOT-ALWAYS MET REQUIREMENT*

Over a decade after Operation Desert Storm and months after Operation Iraqi Freedom, questions remain unanswered about Patriot missile performance during combat operations. The continuing dispute over claims about and analysis of Patriot success (and failures) during Desert Storm has helped drive what seems likely to be a more robust analysis of Iraqi Freedom activity.

J. Daniel Sherman's article on Patriot PAC-2 development in the Winter 2003 *Acquisition Review Quarterly* failed to capture appropriately the validity issues in analysis of the Desert Storm experience. Understanding the dispute over Patriot claims and analysis suggests the criticality of robust analysis of operational performance for an acquisition community that is being asked to focus on spiral development and acquisition—a focus that implies the ability to bring real-world lessons into programs in an effective and efficient manner.

To start with, the PAC-2 article does not put the Desert Storm experience in a correct historical context. Sherman asserts that Iraqi "use of its weapon of terror by launching Scud missile attacks" represented "the first time that tactical ballistic missiles would be used in hostile wartime attacks on civilian populations" (Sherman, 2003, p. 41–42).

In fact, use of missiles during wartime goes back centuries. The British Army used rockets to attack and set ablaze Boulogne, France, in 1806. During World War II, the Germans launched 2,952 V-2 ballistic missiles at cities in England and on the Continent. (These missiles killed 2,724 and wounded 6,467 in England and killed 4,152 in Belgium.) During the Iran-Iraq War, the two sides shot a total of 266 missiles during the "War of the Cities" (Greenwald, 1995). Missiles have long been used to threaten and attack civilians. Prior to Desert Storm, there seemed to be no effective active defense against this threat. The Patriot seemed to offer a path to change this calculus.

During Operation Desert Shield, the United States deployed Patriot batteries to Saudi Arabia and Israel. At the end of Desert Storm, both within the U.S. military and in the public discussion, the impression was that Patriot had performed spectacularly, effectively blunting the Iraqi Scud missile threat. Sherman cites February 28, 1991, estimates of successful Patriot interception rates of 70 percent in Saudi Arabia and 40 percent in Israel (Sherman, 2003). Thus, despite the death of 28 Americans in a February 25, 1991 Scud strike on Dhahran, Saudi Arabia, and other deaths, the Patriot performance was being rated a stunning technological success in the rapid adaptation of a system to undertake a more demanding mission than that for which it was originally designed.

In the 12 years since, however, the open analysis of Patriot performance has called into question the conclusion of tactical success. Questions have been raised about data collection, evidence standards, and measures of effectiveness. For example, some have challenged the standard for success.

> The Army classified an engagement as a success if it could satisfy three criteria. (1) An engageable Scud must be present, (2) The "PATRIOT must intercept the Scud (i.e., detect, launch, and guide to intercept)," and (3) "There must be no significant ground damage."
>
> The first criterion—requiring that an engageable Scud be present — clearly is trivial.
>
> Criterion 2 ... might sound like a more demanding requirement. However, the term "intercept" does not imply that the Scud was hit or in any way damaged, it only means that at least one Patriot flew out to the general vicinity of the Scud. ...
>
> By satisfying criteria 1 and 2, the Army is in effect establishing that a Scud was present and that at least one Patriot fired against it did not grossly malfunction. All that is needed ... to declare such an engagement to be a success is that ... no significant ground damage occurred. ... Even in cases where Patriot radar tracking data indicates that the Scud would have impacted in a completely uninhabited area ... resulting lack of damage is taken as positive evidence ... even if there is unambiguous evidence that a Scud warhead hit the ground and exploded, the Army's methodology would still allow the engagement to be classified as a success. (Lewis & Postal, 2000, pp. 385–386)

Try applying this logic to other systems. Flak jackets, for example, are overwhelmingly effective simply because the vast majority of bullets fired on the battlefield miss.

This author has detailed knowledge of just one Scud missile incident—the February 16, 1991 attack against Al Jubayl, Saudi Arabia. At the time the missile struck, 0207, February 16, the Patriot Battery was down for maintenance. It came back on line at 0212. This maintenance downtime, however, did not affect the effectiveness statistics as it was excluded from the post–war analysis.

For this case, post–war Patriot analysis asserted that there was no detection and that the missile impacted 10 miles north of F/2-7 Battery (F battery of the 2-7 battalion (F/2-7) under the 11th Air Defense Artillery (ADA) Brigade). The missile landed "outside the defended area...confirming that this was a non-threatening SCUD." (CAS Inc, 1992, as cited in Siegel, 2003, pp 31–32) In fact, the missile landed just 150 meters from the pier, less than 1000 meters from USS *Tarawa* (with 2,793 sailors, Marines, soldiers, and civilians [including this author] aboard), and roughly

three kilometers from the battery site. The actual location of the impact was readily available (the missile having been recovered nearly intact from the harbor bottom) yet the Patriot analysis excluded this as a case of potential interest (Siegel, 2003).

Sherman asserts that "Regardless of any controversy regarding the number of Scuds that were destroyed, disabled or diverted, the fact remains: Patriots saved many lives, both civilian and military" (Sherman, 2003, p. 42). In terms of the open discussion regarding Patriot performance, the fact remains that it is unproven whether Patriot saved any lives, whether civilian or military. In fact, some might suggest that unwarranted confidence in the Patriot system and performance failures aggravated by operator processes may have contributed to the death of 28 Americans in the February 25, 1991 Scud attack against Dhahran.

The *fact* of Desert Storm Patriot performance is that the contractor and the Army attempted—within a very tight timeline—to adapt a system from fixed-wing air defense to a far more demanding mission of missile defense with the penalties of doing this with poorly understood parameters of the actual threat (Iraqi Scud) performance. They sought to solve a very real capabilities gap through modifying the existing system. In terms of technical performance, the jury remains out 12 years later, although the question is whether the Patriots had some, minimal, or no tactical capability against the Iraqi missile threat rather than the cited 70 percent success rate. (A robust literature exists on these issues. See, for example: Government Accounting Office (GAO), 1992a; GAO, 1992b; Hildreth, 1992; Lewis & Postal, 1993; Lewis & Postal, 2000; Postal, 1991; Postal, 1992; Stein, 2000; Sullivan, 1998.)

On the other hand, the Patriot was likely of great policy and operational importance. Patriot deployments in Saudi Arabia and Israel reassured both of these governments and their people. The deployment to Israel might have prevented the Israelis from striking back at Iraq and thus helped keep the coalition together. Thus, the Patriot performance during Operation Desert Storm might be a case of a system with minimal tactical effectiveness but great policy and operational effectiveness.

While such details might seem footnotes to an obscure history, they point to an important issue for the acquisition community. The challenges of the 21st century, the global war on terrorism, and transformation suggest that the U.S. military will frequently go into battle using non-Initial Operating Capability (IOC) systems, will often seek to employ these systems adaptively to confront emergent challenges or exploit new operational concepts, and will seek to bring operational *lessons learned* back into the procurement system as rapidly as possible to enhance future operational capabilities.

To do such adaptive procurement requires that analytically rigorous and objective analysis be applied to mission performance—in technological, procedural, operational, and even policy terms. When done right, this analysis should begin prior to actual employment (potentially deploying analysts with deployed units and systems) and must build on effective data collection during operations. Unfortunately, beginning data collection and analysis after-the-fact increases the potential for skewed analysis and mistaken conclusions. This analytical process and its results should be shared with all stakeholders—the operators, procurement community, contractors, and

oversight process (whether DoD, administration, or Congressional). In addition, to the extent that security allows, this analysis should be available to the larger defense community to help focus development priorities where merited.

Following Desert Storm, this did occur with some Air Force and Navy programs that were perhaps similarly *experimental*. The Joint STARS program, also deployed for Desert Shield/Storm well before official IOC, closely monitored platform performance during the conflict. The program made a studied effort to learn from the experience in both the technical and procedural realms. On the other hand, the deployed experience was specifically excluded from the Operational, Test and Evaluation (OT&E) process. Rather than using the real-world experience to accelerate the formal fielding of the program, this experience was viewed by at least some as an inhibitor to program development (Fowler, 1998).

When Iraq invaded Kuwait in 1990, the Navy Tomahawk cruise missile had never been fired in anger. From Desert Storm until today, the U.S. Navy has had a team at the Center for Naval Analyses (key members have included Richard Brody, Stuart Dunn, and Robbin Holliday) to attempt to reconstruct the events and effectiveness of virtually every Tomahawk strike. Their Desert Storm work was at odds with original performance claims during the *heat of battle* (Holliday, 1994), but the analytical rigor led the Navy to accept and eventually embrace their work to help drive future program decisions.

For neither the Joint STARS nor the Tomahawk community were all lessons necessarily *pleasant*. Both communities undertook, however, a serious effort to assess system capabilities as honestly as possible to enhance future performance of what was in one case essentially an experimental platform and, in the other, an untried weapon system when Iraq invaded Kuwait.

As far as this author is aware, this did not occur with Patriot performance during Operation Desert Storm. Sherman's article on PAC-2 development continues a too-strong tradition of failing to evaluate Desert Storm Patriot performance in an open, honest, forthright, and analytically defensible manner. The assignment of a Defense Science Board (DSB) to examine Patriot performance during Operation Iraqi Freedom (Wall, 2003; Wynne, 2003) provides grounds for hope that this error will not be repeated with this Gulf War's Patriot employment analysis. (For initial open publication analysis of Operation Iraqi Freedom Patriot employment, see, for example, Ghormley, 2003.)

The acquisition community should place a high priority on capturing meaningful lessons from operations—especially for systems that have not yet achieved IOC. This experience should be leveraged to expedite fielding the most effective systems in the most appropriate fashion amid the challenges of 21st century spiral development.

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References

CAS Inc. (1992, July 25). Weapon Systems Analysis. *Patriot performance assessment in Desert Storm roadmap.* Huntsville, AL: Author.

Fowler, C. A. (1998, March 11). *The standoff observation of enemy ground forces: From project PEEK to Joint Stars.* Speech given to the MIT Security Studies Program.

General Accounting Office (GAO). (1992a, April 7). *Operation Desert Storm: Project manager's assessment of Patriot missile's overall performance is not supported.* (GAO/NSIAD-92-27). Washington, DC: Author.

General Accounting Office (GAO). (1992b, February). *Patriot missile defense: Software problem led to system failure at Dhahran, Saudi Arabia.* (GAO/IMTEC-92-26). Washington, DC: Author.

Greenwald, B. E. (1995, October). *Scud alert! The history, development, and military significance of ballistic missiles on tactical operations.* (Land Warfare Paper no. 22). Arlington, VA: Institute of Land Warfare, Association of the U.S. Army.

Gormley, D. M. (2003-2004, Winter). Missile Defence Myopia: Lessons from the Iraq War. *Survival, 45*(4) 61-81.

Hildreth, S. (1992, April 7). *Evaluation of the U.S. Army assessment of Patriot anti-tactical missile effectiveness in the war against Iraq.* Congressional Research Service, at "Oversight Hearing on the Performance of the Patriot Missile in the Gulf War," House Committee on Governmental Operations.

Holliday, M. R., et al. (1994). *TLAM performance during Operation Desert Storm: Assessment of physical and functional damage to the TLAM aimpoints* (Vol. I, Overview and Methodology). Alexandria, VA: Center for Naval Analyses.

Lewis, G. N., & Postal, T. A. (1993). Video evidence on the effectiveness of Patriot during the 1991 Gulf War. *Science and Global Security, 4*(1), 1–63.

Lewis, G. N., & Postal, T. A. (2000). Technical debate over Patriot performance in the Gulf War: American physical society panel correctly rejects criticisms of analysis showing Patriot failed to destroy SCUD warheads. *Science & Global Security, 8*, 357–398.

Postal, T. A. (1991, Winter). Lessons of the Gulf War experience with Patriot. *International Security, 16*(3), 119–171.

Postal, T. A. (1992, Summer). Correspondence: Patriot experience in the Gulf War. *International Security*, *17*(2), 199–240.

Sherman, J. D. (2003, Winter). Patriot PAC-2 development and deployment in the Gulf War. *Acquisition Review Quarterly*, *10*(1), 29–45.

Siegel, A. B. (2003). Missile defense at the waterfront: Implications of the SCUD missile attack on Al Jubayl Port, February 15–16, 1991. *Defense and Security Analysis*, *19*(1), 15–33.

Stein, R. M., et al. (2000). Response to *Science & Global Security* article "Technical debate over Patriot performance in the Gulf War" by Jeremiah Sullivan, et al. *Science & Global Security*, *8*, 217–259.

Sullivan, J. D., et al. (1998). *Technical debate over Patriot performance in the Gulf War.* ACDIS Research Report, University of Illinois, Urbana-Champaign (April 4, 1998) (version published in *Science & Global Security*, *8*).

Wall, R. (2003, July 7). Dangerous missile mix sparks scrutiny. *Aviation Week & Space Technology*, 47–48.

Wynne, M. W. (2003, June 3). Memorandum for Chairman, Defense Science Board: Terms of reference —DSB task force on Patriot system performance. Washington, DC: Author.

DEFENSE ACQUISITION REVIEW GUIDELINES FOR CONTRIBUTORS

The *Defense Acquisition Review Journal (ARJ)* is a scholarly peer-reviewed journal published by the Defense Acquisition University (DAU). All submissions receive a blind review to ensure impartial evaluation.

In General

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Authors should become familiar with the construction of previous *Defense ARJ*s and adhere to the use of endnotes versus footnotes, formatting of bibliographies, and the use of designated style guides. It is also the responsibility of the corresponding author to furnish government agency/employer clearance with each submission.

Submissions

We welcome submissions from anyone involved in the defense acquisition process. Defense acquisition is defined as the conceptualization, initiation, design, development, testing, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services needed by the Defense Department, or intended for use to support military missions.

Research Articles

Manuscripts should reflect research or empirically supported experience in one or more of the aforementioned areas of acquisition. Research, lessons learned or tutorial articles should not exceed 4,500 words. Opinion articles should be limited to 1,500 words.

Research articles are characterized by a systematic inquiry into a subject to discover/revise facts or theories.

Manuscript Sections

A brief abstract provides a comprehensive summary of the article and must accompany your submission. Abstracts give readers the opportunity to quickly review an articles' content and also allow information services to index and retrieve articles.

The introduction, which should not be labeled, opens the body of the paper and states the problem being studied and the rationale for the research undertaken.

The methods section should include a

detailed methodology that clearly describes work performed. Although it is appropriate to refer to previous publications in this section, the author should provide enough information so that the experienced reader need not read earlier works to gain an understanding of the methodology.

The results section should concisely summarize findings of the research and follow the train of thought established in the methods section. This section should not refer to previous publications, but should be devoted solely to the current findings of the author.

The discussion section should emphasize the major findings of the study and its significance. Information presented in the aforementioned sections should not be repeated.

Research Considerations

Contributors should also consider the following questions in reviewing their research-based articles prior to submission:

- Is the research question significant?
- Are research instruments reliable and valid?
- Are outcomes measured in a way clearly related to the variables under study?
- Does the research design fully and unambiguously test the hypothesis?
- Did you build needed controls into the study?

Contributors of research-based submissions are also reminded they should share any materials and methodologies necessary to verify their conclusions.

Criteria For Tutorials

Tutorials should provide special instruction or knowledge relevant to an area of defense acquisition to be of benefit to the Department of Defense Acquisition, Technology, and Logistics Workforce.

Topics for submission should rely on or be derived from observation or experiment, rather than theory. The submission should provide knowledge in a particular area for a particular purpose.

Opinion Criteria

Opinion articles should reflect judgments based on the special knowledge of the expert. Opinion articles should be based on observable phenomena and presented in a factual manner; that is, submissions should imply detachment. The observation and judgment should not reflect the author's personal feelings or thoughts. Nevertheless, an opinion piece should clearly express a fresh point of view, rather than negatively criticize the view of another previous author.

Manuscript Style

We will require you to recast your last version of the manuscript, especially citations (endnotes instead of footnotes) into the format required in two specific style manuals. The *Defense ARJ* follows the

author (date) form of citation. We expect you to use the *Publication Manual of the American Psychological Association* (5th Edition), and the *Chicago Manual of Style* (14th Edition).

Contributors are encouraged to seek the advice of a reference librarian in completing citations of government documents because standard formulas of citations may provide incomplete information in reference to government works. Helpful guidance is also available in Garner, D. L. and Smith, D. H., 1993, *The Complete Guide to Citing Government Documents: A Manual for Writers and Librarians* (Rev. Ed.), Bethesda, MD: Congressional Information Service, Inc.

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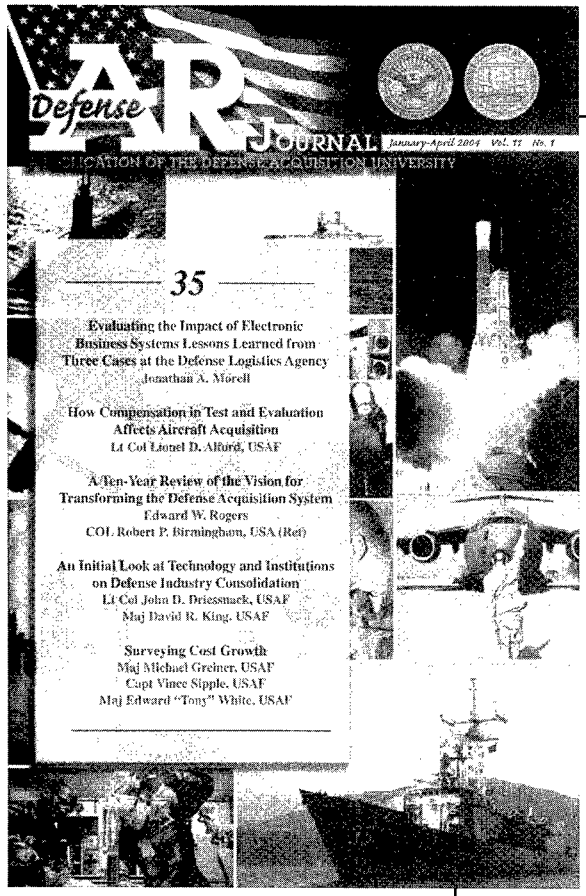

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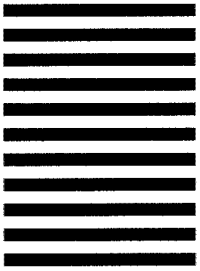

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